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DESIGN AND COST ESTIMATES FOR A  
**CONNECTING CHANNEL BETWEEN  
EAST DEVILS LAKE AND  
WEST STUMP LAKE**

**DEVILS LAKE BASIN  
North Dakota**

prepared for  
U.S. ARMY CORPS OF ENGINEERS  
ST. PAUL DISTRICT

MARCH 1986

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BARR ENGINEERING CO.

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DESIGN AND COST ESTIMATES FOR CONNECTING CHANNEL  
BETWEEN EAST DEVILS LAKE AND WEST STUMP LAKE  
DEVILS LAKE BASIN, NORTH DAKOTA

EXECUTIVE SUMMARY

The water surface elevations of the Devils Lake chain of lakes have been rising over the past several decades. Several alternatives are being considered to alleviate the rising lake levels which are approaching levels where potential for significant damage to adjacent property exists. A connecting channel approximately 10 miles long from East Devils Lake to West Stump Lake, which is an important segment of several different alternatives for an outlet channel for the Devils Lake chain of lakes, is the subject of this report.

Preliminary designs for thirteen alternative connecting channel cases have been developed. The preliminary designs are the basis for the generation of cost estimates for each of the thirteen cases. The cost estimates include all capital costs for construction of the connecting channel, except that easement and right-of-way acquisition costs are not included. The design conditions and the estimated capital cost for the thirteen alternative connecting channel cases are summarized in the following table.



CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
SUMMARY OF DESIGN CONDITIONS AND ESTIMATED CAPITAL COST

Case	Design Channel Capacity (cfs)	Pump Station Required	Water Surface Elevations (ft.)			Estimated Capital Cost*
			East Devils Lake	Upstream End of Channel	West Stump Lake	
1A	200	No	1430	1430	1410-1425	\$ 5,360,000
1B	600	No	1430	1430	1410-1425	8,400,000
1C	1,000	No	1430	1430	1410-1425	11,200,000
2G	200	No	1435	1435	1410-1425	3,920,000
2P	200	Yes	1430	1435	1410-1425	5,890,000
3A	200	Yes	1430	1440	1410-1425	4,540,000
3B	600	Yes	1430	1440	1410-1425	9,980,000
3C	1,000	Yes	1430	1440	1410-1425	14,500,000
4L	200	Yes	1430	1445	1410-1425	4,120,000
4H	200	Yes	1435	1445	1410-1425	4,090,000
5A	200	Yes	1430	1450	1410-1425	4,890,000
5B	600	Yes	1430	1450	1410-1425	9,690,000
5C	1,000	Yes	1430	1450	1410-1425	13,400,000

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\*Capital cost does not include costs for easements and right-of-way acquisition.

DESIGN AND COST ESTIMATES FOR A CONNECTING CHANNEL BETWEEN  
EAST DEVILS LAKE AND WEST STUMP LAKE  
DEVILS LAKE BASIN, NORTH DAKOTA

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DESIGN AND COST ESTIMATES FOR CONNECTING CHANNEL  
BETWEEN EAST DEVILS LAKE AND WEST STUMP LAKE  
DEVILS LAKE BASIN, NORTH DAKOTA

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to provide part of the basis for the continued screening of outlet alternatives from the presently landlocked Devils Lake chain of lakes. It describes the further development of preliminary designs and cost estimates for the section of outlet channel between East Devils Lake and West Stump Lake for a variety of conditions. Designs and cost estimates have been completed to a feasibility study level of detail.

1.2 Background

The St. Paul District, Corps of Engineers, is currently conducting feasibility level flood control studies in the Devils Lake Basin, North Dakota. The water surface elevation of Devils Lake has been rising over the past several decades and is now approaching levels where the potential for significant damages exists if the lake level continues to rise. The Devils Lake chain of lakes does not have a natural outlet until the lake level reaches an elevation of about 1457, approximately thirty feet above its current level. At that elevation, water would flow from Devils Lake through East Devils Lake and West Stump Lake into Tolna Coulee and then into the Sheyenne River near Tolna, N.D. Several alternatives are being considered to

alleviate the problems caused by the rising lake level. Of prime consideration are a series of outlet channels from the Devils Lake chain of lakes to the Sheyenne River.

Preliminary designs and cost estimates have been developed by the Corps for the outlet channel alternatives from the Devils Lake chain of lakes to the Sheyenne River. These designs were developed from the first screening of alternatives using 7.5 minute U.S.G.S. topographic maps as the basis for elevation information. A connecting channel from East Devils lake to West Stump Lake, an important segment of several different outlet channel alternatives, is the subject of this report.

## 2. SPECIFIED DESIGN CONDITIONS

The following paragraphs list the general conditions considered in the design of the connecting channel.

### 2.1 Channel Capacity

Three alternative channel capacities have been evaluated: 200 cubic feet per second (cfs), 600 cfs, and 1000 cfs. The channel has been designed to be stable for these conditions. Designs for culverts at road crossings, berms, drop structures, inlet and outlet plans, erosion protection, and all appurtenant features are included.

### 2.2 Water Surface Elevations

Two different design water levels were considered at East Devils Lake: Elevation 1430 and 1435. Elevation 1430 was used for the majority of the options. (All elevations in this report are referenced to NGVD, 1929).

The design water surface elevation at the upstream end of the channel varied from Elevation 1430 to Elevation 1450. Gravity flow was assumed from this point to West Stump Lake. In most cases, a pump station was included to raise the water from East Devils Lake to the starting elevation for gravity flow at the upper end of the channel.

The channel was designed to provide for West Stump Lake water levels ranging from Elevation 1410 to Elevation 1425, while maintaining the design channel capacities.

To minimize impact on the Black Swan Wildlife Management Area, the design water surface elevation was required not to exceed Elevation 1436 (one foot below the open water surfaces in the management area) in the reaches of the channel passing through the management area.

### 2.3 Summary of Design Conditions

Thirteen cases for consideration were derived from the above conditions. Table 2-1 lists the case designations and the design capacity and water surface elevations for each case.

Cases 1A, 1B, 1C, and 2G are gravity flow from East Devils Lake to West Stump Lake. Cases 2P, 3A, 3B, 3C, 4L, 4H, 5A, 5B and 5C require a pump station to lift the water from East Devils Lake to the upstream end of the channel where flow will be by gravity to West Stump Lake.

Seven of the cases have a design discharge capacity of 200 cfs, three have a design capacity of 600 cfs, and three have a design capacity of 1,000 cfs.

TABLE 2-1 List of Evaluated Conditions

<u>Case</u>	<u>Channel Capacity (cfs)</u>	<u>Water Surface Elevations</u>		
		<u>East Devils Lake (ft.)</u>	<u>Upstream End of Channel (ft.)</u>	<u>West Stump Lake (ft.)</u>
1A	200	1430	1430	1410-1425
1B	600	1430	1430	1410-1425
1C	1000	1430	1430	1410-1425
2G (gravity)	200	1435	1435	1410-1425
2P (pump)	200	1430	1435	1410-1425
3A	200	1430	1440	1410-1425
3B	600	1430	1440	1410-1425
3C	1000	1430	1440	1410-1425
4L (low)	200	1430	1445	1410-1425
4H (high)	200	1435	1445	1410-1425
5A	200	1430	1450	1410-1425
5B	600	1430	1450	1410-1425
5C	1000	1430	1450	1410-1425

### 3. CHANNEL DESIGN

The primary consideration for channel design was to provide the desired capacity under the design conditions discussed in Section 2 at minimum cost. Secondary considerations included controlling environmental impact and providing a system which is easily and economically operated.

Discussion of the channel design for each of the cases listed in Section 2 is separated into eight areas:

- (1) channel alignment;
- (2) main channel from Station 38+00 upstream to the pump station (or to East Devils Lake for Cases 1A, 1B, 1C, and 2G, which require no pump station);
- (3) inlet channel from East Devils Lake to the pump station;
- (4) outlet channel (the downstream reach of the channel from Station 38+00 to West Stump Lake);
- (5) culverts at road crossings;
- (6) channel erosion protection;
- (7) road raises, and
- (8) appurtenant features.

Location maps showing the features of each of the alternative case designs are provided on Plates A-1 through A-8 in Appendix A.

#### 3.1 Channel Alignment

The initial step in the channel design was selection of a channel alignment. The area considered for channel alignment was limited to the naturally low wetland area between East Devils Lake and West Stump Lake. Topographic maps for this area with a scale of one inch equals 400 feet and contour intervals of two feet generated from aerial photographs taken April, 1985 were the primary source of information used in channel alignment selection. The April,

1985 aerial photos, wetland maps, and USGS topographic maps were also reviewed. The selected channel alignment shown on Plates 1 and 2 was used for all the considered cases described in Section 2. The alignment for Cases 5A, 5B, and 5C varies slightly at the upstream end from the alignment for the other cases and is indicated on Plate 1.

The basis for channel alignment selection was economy of construction and minimization of adverse environmental impacts. For economy of construction (minimum excavation), the channel alignment was chosen through the low portions of the study area and an attempt was made to select the shortest alignment. To minimize impact on the wetlands, the channel alignment was chosen to skirt the major wetland areas. Of particular concern was the portion of the channel (approximately Station 0+00 to Station 180+00) passing through the Black Swan Wildlife Management Area.

### 3.2 Main Channel

#### 3.2.1 General Assumptions

Six general assumptions which governed the hydraulic design of the channel are discussed below. The sensitivity of the channel designs to changes in the design assumptions is discussed in Section 3.9.

- (a) Channel cross section would have a ten-foot bottom width and three horizontal to one vertical side slopes (Plate 3). Early in the investigation, it was found that varying the bottom width of the channel had little impact on volume of excavation required and, therefore, excavation cost for a given discharge capacity. Ten feet was chosen for the design because it is the practical



minimum width for excavation with large earth moving equipment. It was assumed that the majority of the excavation for the channel would be done with a dragline because of difficulties associated with excavation below the water table with other excavation equipment. Three to one side slopes were chosen as a conservative design because of the limited information available on the soils in the channel alignment area.

- (b) Manning's roughness coefficient of 0.035 would be used for the channel. Because of uncertainty as to the hydraulic condition of the channel, which will be used intermittently, a conservatively high "n" value was chosen.
- (c) Maximum allowable design channel velocity would be two feet per second. To minimize erosion potential, this relatively low maximum velocity was chosen.
- (d) Design would attempt to minimize cost. Preliminary cost estimates for several channel profiles were developed considering only the costs of the two major items; excavation and culverts at the road crossings. A general trend for optimization (minimization) of the costs associated with excavation and culverts was identified and applied to the channel designs described below.

For Cases 1A, 1B, 1C and 2G and 2P, little variation in the design could be realized because of the small amount of available head. For the other cases, it was found that by steepening the slope at the downstream end of the channel and maintaining flatter slopes at the upstream end (in general, paralleling the existing ground surface), the excavation costs were minimized and the savings in excavation costs more than offset increases in the culvert costs. The optimization of the design for each case is discussed in subsections 3.2.2 through 3.2.6.

- (e) Channel design for all cases would assume West Stump Lake to be at its maximum level of Elevation 1425. The design of the outlet portion of the channel provides for a possible fifteen-foot fluctuation in the West Stump Lake water level (from Elevation 1410 to Elevation 1425) and is discussed in detail in Section 3.4
- (f) Head losses would be achieved through culverts. In general, the majority of headloss through the channel system other than channel friction losses was assumed to be through submerged culverts (outlet control) at road crossings. Designing for the loss of head through the culverts was chosen instead of providing drop structures because of the large cost savings which could be realized by eliminating the need for large drop structures. Culverts (or

bridges) would be required at the road crossings in any case and increasing the design head loss at the culverts reduces their required size and cost.

### 3.2.2 Cases 1A, 1B, and 1C

These cases are all completely gravity flow and do not require a pump station. Design capacities are 200, 600, and 1,000 cfs for Cases 1A, 1B and 1C, respectively. There is five feet of head difference between East Devils Lake (Elevation 1430) and West Stump Lake at its maximum level (Elevation 1425) for all three cases.

Plate B-1 in Appendix B illustrates the channel profile for Cases 1A, 1B, and 1C. Channel cross sections at 13 typical locations are illustrated on Plates C-1 through C-13 in Appendix C. The design water surface elevations are the same for each case; the channel bottom elevations change to provide for the various capacities.

The five feet of head available for Cases 1A, 1B and 1C limited the channel design options. To optimize the design, trial designs were made using various distributions of the available head between losses at the seven culverts and channel friction losses. Increasing the head loss through the culverts requires smaller culverts, decreasing their cost, but the increased channel depth required to reduce the channel friction losses results in increased excavation cost. Decreasing culvert head loss and increasing the available head for channel friction losses has the opposite effect, increased culvert costs and reduced excavation cost.

Balancing the design head losses through the culverts with those in the channel resulted in the design with lowest cost for Cases 1A, 1B and 1C. The design head loss at each culvert was 0.4 feet. The remaining 2.2 feet of head is consumed by channel friction losses.

### 3.2.3 Case 2G and 2P

Both Case 2G and 2P have a channel capacity of 200 cfs and a design water surface elevation of 1435 at the upstream end of the channel. Case 2P requires a pump station to lift water from East Devils Lake at Elevation 1430 to Elevation 1435 at the upstream end of the channel. In Case 2G, East Devils Lake is assumed to be at Elevation 1435 and gravity flow conditions exist throughout the channel.

Plates B-2 and B-3 in Appendix B illustrate the channel profiles for Cases 2G and 2P, respectively. Channel cross sections at thirteen typical locations for Cases 2G and 2P, respectively, are shown on Plates C-14 through C-26 and on Plates C-27 through C-39 of Appendix C.

The total system head drop of ten feet is higher than Cases 1A, 1B, and 1C, but changes in the culvert design head losses were still not advantageous. The design head loss of 0.4 feet at each culvert was kept the same. An increase in the channel slope accounted for the extra five feet of head. The channel slope for Case 2P is slightly higher than that for Case 2G since Case 2P has a shorter channel length.

#### 3.2.4 Case 3A, 3B, and 3C

A pump station is required with a capacity of 200 cfs, 600 cfs or 1,000 cfs, respectively, for Cases 3A, 3B and 3C to elevate water from East Devils Lake at Elevation 1430 to Elevation 1440 at the upstream end of the channel.

Plate B-4 in Appendix B illustrates the design channel profiles for these cases. Channel cross sections at thirteen typical stations are shown in Plates C-40 to C-52 in Appendix C.

The total system head drop of fifteen feet allowed for further optimization of excavation and culvert costs. The natural ground slope in the channel from Station 200+00 to the inlet is relatively flat. Beyond this reach the ground surface slopes significantly to the outlet. Following this trend with the channel slope and adjusting the culvert head losses, an optimum design condition was chosen. The three upstream culverts have relatively low design head losses (0.4 and 0.5 feet). The three downstream culverts have larger design head losses (1.5 to 4.1 feet).

#### 3.2.5 Cases 4L and 4H

Cases 4L and 4H are essentially the same except for the lift required of the pump station. Both cases require a 200 cfs channel capacity and a water surface elevation of 1445 at the upstream end of the channel. East Devils Lake is at Elevation 1430 for Case 4L and Elevation 1435 for Case 4H.

Plate B-5 in Appendix B illustrates the channel profile for Cases 4L and 4H. Plates C-53 through C-66 in Appendix C show cross sections at thirteen typical location for Cases 4L and 4H.

The design of the channel is similar to that of Case 3A; shallow channel slope and low head loss at culverts in the upstream reach of the channel, and steeper slope and higher culvert head losses in the downstream reach. An area between Road Crossing 6 and Road Crossing 7 will be inundated for both Case 4L and 4H. The inundated area is shown on the location map, Plate A-5, in Appendix A.

#### 3.2.6 Cases 5A, 5B, and 5C

Special treatment was used to design the main channel for these cases due to the high total available head of twenty-five feet. A pump station is used to elevate the water from Elevation 1430 in East Devils Lake to Elevation 1450 in the upstream end of the channel. Pump and channel capacities of 200 cfs, 600 cfs, and 1000 cfs are required for Cases 5A, 5B, and 5C, respectively.

Plate B-6 in Appendix B illustrates the channel profile. Cross sections at thirteen typical locations are shown on Plates C-67 through C-79 in Appendix C.

Upstream of road crossing 4, the low wetland areas will be inundated, providing a wide, relatively shallow waterway. The inundated area is shown on the location map, Plate A-7, in Appendix A. From road crossing 4 to the outlet, the majority of the head loss was achieved through culverts.

To minimize excavation in the upstream reach of the channel, the channel centerline is slightly different than the excavated channel alignment for the other cases. The lowest ground elevation along the channel route chosen for the Case 5A, 5B and 5C alignments is shown on the channel profile (Plate B-6 in Appendix B). With the upstream design water surface elevation at 1450, between road crossing 4 and the pump station, excavation was required only for widening the natural channel between Station 288+00 and Station 352+00.

### 3.3 Inlet Channel

An inlet channel was required for the cases with pump stations (Cases 2P, 3A, 3B, 3C, 4H, 4L, 5A, 5B and 5C). The inlet channel bottom widths for 200 cfs, 600 cfs, and 1000 cfs were twenty-five, forty-five and sixty feet, respectively, based on the assumed intake structure dimensions required at the pump station (supplied by the Corps). Assuming a maximum channel velocity of two feet per second, three horizontal to one vertical side slopes and a Mannings roughness coefficient of 0.035, the channel flow depth required for all three discharges is approximately 4.5 feet. The inlet channel cross section is shown on the cross section at Station 514+00 and is included in Appendix C for all the cases requiring a pump station (Plate C-39, Case 2P; Plate C-52, Cases 3A, 3B and 3C; Plate C-65, Case 4L; Plate C-66, Case 4H; and Plate C-79, Cases 5A, 5B, and 5C).

### 3.4 Outlet Channel

The potential for variable water surface levels in West Stump Lake and the fact that the main channel designs were

based on the assumption that West Stump Lake was at its maximum level, required that treatment be considered for the steep downstream portion of the channel. When the West Stump Lake water level drops below Elevation 1425, the maximum permissible channel velocity of two fps could be exceeded in the outlet portion of the channel (West Stump Lake to Station 38+00).

Two options were considered in the channel outlet design. The first option utilized a steep riprapped channel into West Stump Lake. The second used drop structures to provide a rapid change in grade and reduce channel velocities. Preliminary cost estimates demonstrated the drop structures to be sixty percent less expensive than a riprapped channel. Therefore, drop structures were chosen as an integral part of the outlet channel design. Control of the channel capacity is maintained by the weir elevation of the drop structure.

Drop structures were located at approximately Stations 28+00 and 38+00. The basic design was adapted from the Corps of Engineer Manual, Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Plate 43. This design is very similar to that of a Type B Soil Conservation Service (SCS) drop structure described in the SCS National Engineering Handbook Section 11, ES-67. Plate 4 shows the typical drop structure design.

Table 3-1 summarizes the information for the drop structures for the 200 cfs, 600 cfs, and 1000 cfs design discharges.

For the 600 cfs and 1000 cfs discharges, the channel bottom width for the outlet channel downstream of the first drop structure at Station 38+00 is the same width as the weir length; thirty feet and fifty feet, respectively. The



TABLE 3-1 Drop Structure Information

Discharge (cfs)	Weir Length L (ft)	Head H (ft)	Drop F (ft)	Basin Length L <sub>b</sub> (ft)	Approx. Crest Elevation	
					at Sta 38+00	at Sta 28+00
200	10	3.5	8	13.3	1421.5	1414.0
600	30	3.5	8	13.3	1421.5	1414.0
1000	50	3.5	8	13.3	1421.5	1414.0

outlet channel width was maintained for the remaining channel length into West Stump Lake. To prevent the downstream drop structure from being overtopped and damaged by erosion when the West Stump Lake elevation rises, the headwall and adjacent berms have five feet of freeboard above the Elevation 1425 high water level. The outlet channel cross section is shown on the cross section at Station 25+00 and is included in Appendix C for all the cases (Plate C-1, Cases 1A, 1B, and 1C; Plate C-14, Case 2G; Plate C-27, Case 2P; Plate C-40, Cases 3A, 3B, and 3C; Plate C-53, Cases 4L and 4H; and Plate C-67, Cases 5A, 5B, and 5C).

### 3.5 Culverts at Road Crossings

Generally, there are two design conditions for the culverts at the road crossings: those with low head loss (approximately 0.4 to 0.5 feet), and those with high head loss (1.0 to 5.8 feet). The first condition requires relatively large culverts to pass the flow with low head loss. Exit velocities from these culverts are between three and four feet per second. The high head loss condition offers the advantage of smaller culvert size but has culvert exit velocities ranging from five to thirteen feet per second. Riprapping for erosion protection at the exits of both low head loss and high head loss culverts is discussed in Section 3.6. Culvert slopes were restricted to a maximum of one percent. Plates 5 through 8 illustrate typical road crossings for both low and high head loss conditions. The required culvert size was based on nomographs for full flow (outlet control), with an assumed entrance loss coefficient of 0.7.

For the completely gravity flow cases (1A, 1B, 1C and 2G), the upstream end of the culverts at road crossing 7 will be

fitted with slide gates. The gates will allow the connecting channel to be closed during non-operational periods and will allow adjustment in the quantity of discharge during operation of the channel.

For all design options, the upstream ends of the culverts at road crossings 1 through 6 and the downstream end of the culverts at road crossing 7 will have stoplog slots in them. Stoplogs will be placed in the slots during non-operational periods so that the water level in the channel may be maintained near the existing surface water levels in the wetlands adjacent to the connecting channel.

The operation of the culvert gates and stoplogs are discussed further in Section 5.

### 3.6 Channel Erosion Protection

Since the design channel velocities were restricted to two feet per second, no erosion protection is needed in the channel except at the outlet of the road crossing culverts. For the low head loss culverts (exit velocities of three to four fps), a riprap blanket was provided downstream of the culvert outlet (Plate 5). The length of the blanket, twenty-five, thirty, and thirty-five feet for the 200 cfs, 600 cfs, and 1,000 cfs discharges, respectively, was based on Hydraulic Design Chart 722-5 developed by the U.S. Army Engineer Waterways Experiment Station (WES).

For the high head loss culverts (exit velocities of five to thirteen fps), a riprapped preformed scour hole was provided for energy dissipation and erosion protection. The preformed scour hole design (Plate 9) was based on WES Hydraulic Design Chart 722-6.

The  $D_{50}$  size of riprap chosen for both applications is six inches. The riprap size was based on WES Hydraulic Design Chart 722-7. The riprap thickness for both applications was assumed to be ~~twelve~~<sup>18</sup> inches, the minimum thickness necessary for practical placement.

### 3.7 Road Raises

Five feet of freeboard was assumed to be required at each road crossing. The design assumes four horizontal to one vertical side slopes and a thirty-two foot wide road surface. Four inches of aggregate for the road topping was assumed. A one foot thick riprap layer on the embankment slopes from three feet below the design water surface to three feet above (vertically) was assumed for Cases 4L, 4H, 5A, 5B and 5C, where permanently inundated areas meet the roadway embankment. A typical road raise is shown on Plate 10.

### 3.8 Appurtenant Features

#### 3.8.1 Lateral Inflow Culverts

An analysis was made of the runoff rate from the areas adjacent to the channel. Assuming runoff from one side of the channel along a one mile length (an average drainage area of 240 acres) and a ten-year return period, estimates of peak discharges, made by using the Soil Conservation Service, Rational, and Cook methods, range from 95 cfs to 215 cfs. The Rational method, which gives a value of 161 cfs, was used for the design. These estimates do not include the effect of any ponding adjacent to the channel, which could greatly reduce the discharges at some locations.

Assuming two culverts per mile per side of channel, between eight and twenty-four culverts, each with a capacity of approximately 80 cfs, were required for the thirteen cases. Assuming outlet control, a manhole entry, approximately 4 feet of head in the manhole and 100 feet of pipe exiting into the bottom of the channel, a thirty-six inch culvert is required. Plate 11 shows a typical lateral inflow culvert. Approximate locations of lateral inflow culverts for each of the connecting channel design cases are shown on the location maps in Appendix A.

### 3.8.2 Berms

A berm is required to prevent overtopping and erosion damage at the downstream drop structure at Station 28+00. Including five feet of freeboard, the top of the berm should be at Elevation 1430. The berm extends from the existing ground at Elevation 1430 on the right side of the channel to the Elevation 1430 level of the roadway on the left side, a total length of approximately 2,100 feet.

Cases 3A, 3B, 3C, 4L, 4H, 5A, 5B, and 5C require a berm on the upstream side of the roadway at Station 40+00 on the left side of the channel to prevent overflow into Swan Lake. Including five feet of freeboard, the top of the dike should be at Elevation 1434 and extend from the roadway approximately 650 feet northeast to existing ground at Elevation 1434.

The locations of the berms are included on the location map plates in Appendix A.

### 3.9 Design Sensitivity

The designs of the thirteen connecting channels are based on several assumptions. The major general design assumptions were presented in Section 3.2.1. Other case-specific assumptions were mentioned in the descriptions of the channel and channel features designs in the remainder of Section 3.

The two major features of the connecting channel, the excavated channel and the road crossing culverts, each have a corresponding design assumption associated with them. The assumption associated with the excavated channel is the Manning's "n" value which describes the channel's "roughness" and hence the frictional head losses for the discharge through the channel. The assumption associated with the culverts is the head loss which will be realized through the structure.

The impact on the designs of changes in the assumed "n" value and culvert head losses was examined. In general, an "n" value lower than the assumed 0.035 would increase channel velocities and decrease flow depth in the channel. The assumed value of 0.035 is probably close to the high end of the possible range of values for the channel which is the reason it was chosen for capacity design. An actual "n" value higher than 0.035 which could possibly be realized if extensive vegetation is allowed to grow in the channel during non-operational periods, would result in decreased channel capacity at a given available head. In general, head losses at a culvert greater than assumed would result in decreased capacity and lower head losses would result in increased capacity.

To determine the magnitude of the effects of changes in the assumed "n" value and assumed culvert head losses, the

design for Case 3A was examined. Case 3A was chosen because the upstream reaches of the channel are similar to the channel for Case 1A, 1B, 1C, 2G and 2P and the downstream reaches are similar to those for Cases 4L, 4H, 5A, 5B and 5C. The 200 cfs discharge was chosen because seven of the thirteen design cases are for the 200 cfs discharge capacity. The effects of five combinations of variations in the "n" value and culvert head losses are discussed below.

- (1) Manning's "n" value lower than assumed. The water surface profile for Case 3A was examined assuming the actual channel "n" value was 0.025 instead of the design value of 0.035. A result of the lower "n" value would be a higher capacity for the channel at the design upstream and downstream water surface elevations. The discharge through the channel would be maintained at the design capacity, however, because of control by the pumps at the upstream end of the channel. (For the cases with completely gravity flow, the design discharge could be maintained by adjusting the slide gates at road crossing seven.)

If the design discharge is maintained, the lower "n" value results in higher computed channel velocities and a shallower computed flow depth in the channel. For Case 3A, the computed channel velocities increase from the design 1.3 fps to 1.7 fps in the steep downstream portion of the channel and from the design 0.9 fps to 1.2 fps in the flat upstream portion of the channel.

The largest increase in channel velocity if the "n" value is lower than assumed occurs for Cases 3C and 5C where the channel bottom has its steepest slope (0.0002 ft./ft.) and the design discharge is maximum

(1,000 cfs). The computed channel velocity with the lower "n" value is 2.6 fps instead of the design 2.0 fps.

For Case 3A, the computed channel flow depths decrease from the design 5.6 feet to 4.8 feet in the steep downstream portion of the channel and from the design 6.9 feet to 6.0 feet in the flat upstream portion of the channel, if the actual "n" value for the channel is 0.025 instead of the design "n" value of 0.035.

The largest change in flow depths resulting from a decreased "n" value occurs where the channel is flat and when the discharge is maximum. For Case 3C (design discharge 1,000 cfs), in the flat upstream portion of the channel (slope 0.000078 ft./ft.), the computed flow depth decreases from 13.8 feet to 12.0 feet.

Based on the examination described above, it is apparent that channel velocities will not be a problem even if the actual roughness of the channel is less than the roughness assumed in the design. The highest computed channel velocity assuming a reduced "n" value was only 2.6 fps.

Decreases in the flow depth in the channel are of concern only in their impact on the performance of the culverts. Lower flow depths at the culverts could cause the discharge capacity of the culvert to revert to inlet control from the designed outlet control.

The culvert designs for Case 3A were examined. The culvert as designed at road crossing two becomes



inlet controlled when the lower flow depths are assumed and would not pass the design discharge with normal depth in the reach upstream of the culvert. The increase in head required to pass the design discharge would result in a channel flow depth approximately one-half foot greater than normal depth in the reach immediately upstream of road crossing two. In this case, the effects of the lower "n" value and the switch to inlet control at the culvert at road crossing two tend to cancel, resulting in a water surface close to the design water surface.

- (2) Culvert head losses greater than assumed. To gage the impact of culvert head losses being greater than the design values, backwater computations were done for Case 3A assuming that head losses which are 25% greater than the design head losses occur at each culvert. The resulting water surface elevation at the pump station was computed to be 0.4 feet above the design water surface elevation. To obtain the design capacity through the connecting channel would therefore require pumping to Elevation 1440.4 instead of the design elevation of 1440.0.
- (3) Manning's "n" value higher than assumed. The water surface profiles for all cases were examined assuming that the actual channel "n" value was 0.045 instead of 0.035. The result was an increase in the computed water surface elevation throughout the channel. All the culverts would remain at outlet control and have the design head loss. The points of concern are the reduction in freeboard, the increased pumping head required at the upstream end of the channel to maintain design capacity, and a decrease in capacity of the gravity flow cases. The

maximum reduction in freeboard is 1.5 feet in Cases 3C and 5C. This is also the maximum increase in pumping head required to maintain the design channel capacity. The channel capacity of all the gravity flow cases would be reduced by 22 percent with the higher "n" value.

- (4) Culvert head loss lower than assumed. All of the design outlet control head losses at the culverts in Case 3A were reduced by 25 percent to assess the effect on the channel design. A backwater analysis demonstrated that there would be a net decrease in water depth at the upstream end of the channel of 0.2 feet. This is equivalent to a slight increase in the channel capacity. The decrease in water depth at the upstream end of the channel is so minor because the depth reductions at the downstream end of the channel, due to reduced culvert headloss, is offset when culverts further upstream revert to inlet control due to low tailwater levels.
- (5) Culvert head loss lower than assumed and decreased "n" value. This is a combination of cases (1) and (4) discussed in the above text. Backwater analysis for Case 3A predicts an approximate decrease in the depth at the upstream end of the channel of 1.2 feet. The discussion presented above in case generally (1) applies to this case also.

In addition to the situations described above, the effect of decreased flow depths on the riprap protection design at the outlet of the culverts was examined. The design criteria for riprap sizing is dependent on the tailwater depth at the culvert outlets. The largest of flow depth reduction

discussed above would result in a maximum drop in tailwater at the culverts of approximately 10 percent and a maximum increase in culvert exit velocity of approximately 11 percent. This would result in an increase in required riprap  $D_{50}$  size of approximately 11 percent. The design  $D_{50}$  size of six inches would still be adequate according to the WES design charts.

The preliminary designs described in this section do not appear to be overly sensitive to reasonable variations which could be anticipated in the design assumptions. Although the effects of variations in the assumptions were examined in detail for Case 3A only, the other alternative design cases can be expected to react similarly.

#### 4. COST ESTIMATES

Cost estimates were developed for the connecting channel between East Devils Lake and West Stump Lake described in the previous sections. Table 4-1 presents the estimated capital cost for construction of the 13 cases evaluated. The costs do not include costs for easements and right-of-way acquisition.

TABLE 4-1  
Connecting Channel  
Construction Cost Estimates \*

<u>Case</u>	A	B	C
	<u>(Q=200 cfs)</u>	<u>(Q=600 cfs)</u>	<u>(Q=1,000 cfs)</u>
1	\$5,360,000	\$8,400,000	\$11,200,000
2G	3,920,000		
2P	5,890,000		
3	4,540,000	9,980,000	14,500,000
4L	4,120,000		
4H	4,090,000		
5	4,890,000	9,690,000	13,400,000

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\* Cost estimates do not include costs for easements and right-of-way acquisition.

Tables D-1 through D-13 in Appendix D present a cost estimate summary for each case, itemized by costs for channel excavation, road crossing culverts, slide gates, drop structures, riprap, road raises, berms and culvert backfill, lateral inflow culverts and pump stations. Also included in the cost estimates are costs for contingencies, engineering and design, and supervision and administration. No operating or maintenance costs are included in the estimates.

The following sections describe the methods and assumptions used to derive the estimated quantities and costs for the items in the cost estimates. In general, unit costs were provided by the Corps. Where these were unavailable, estimates were made from other sources.

#### 4.1 Channel Excavation

Channel excavation consists of excavating the inlet channel, main channel, outlet channel, and excavation for culvert

installation at the road crossings. It was assumed that the soil would be removed from the channel with a dragline and spoiled with a minimum twenty-foot setback from the channel on both sides of the channel except in wetlands. Where the channel excavation encroaches into wetlands berms would be built with select spoil on the wetland side of the channel and all other spoil would be placed on the opposite side of the channel.

The volume of channel excavation was computed using the average end area method. Ground surface elevations were taken from the one-inch equals 400 feet topographic map supplied by the Corps. Cross sections for the computations were located a maximum of 400 feet apart along the channel centerline.

The unit cost assumed for channel excavation was \$0.85 per cubic yard, as supplied by the Corps.

#### 4.2 Culverts

Culverts consist of concrete box culverts and precast reinforced concrete circular pipe (RCP) placed at the road crossings. Stoplog slots and stoplogs for the box culverts and gates for the RCP were considered to be incidental items included in the cost for the pipe.

Costs for the box culverts were computed based on a unit price per cubic yard of concrete. For estimating purposes, the assumed wall thicknesses for the box culverts were as follows: 5'x5' boxes and smaller - eight inches, 6'x6' and 6-1/2'x6-1/2' boxes - ten inches, 7'x7' through 10'by 10' - twelve inches, and boxes larger than 10' x 10' - sixteen inches. Cost for the RCP was based on a unit price per lineal foot of pipe.

The assumed unit price for the box culverts was \$300 per cubic yard of concrete, as supplied by the Corps. The unit price assumed for the RCP was \$50 per lineal foot based on available data. The unit prices were assumed to include all labor and materials for construction and installation of the culverts.

#### 4.3 Slide Gates

The slide gates were assumed to be manually operated steel gates. Approximate costs for the gates were obtained from a major gate manufacturer's Minnesota office.

#### 4.4 Drop Structures

The drop structure designs were based on the standard SCS drop structure presented in the SCS National Engineering Handbook, Section 11. The SCS publication also supplies the estimated volume of concrete required for the construction of the drop structures. The cost of the drop structures was computed based on the estimated concrete volume at a unit price of \$300 per cubic yard. The price is assumed to include all materials (concrete, steel, formwork) and labor to construct the drop structures.

#### 4.5 Riprap

The estimated riprap quantity includes riprap to be placed at the outlet of all the road crossing culverts. Riprap placed along the road embankments adjacent to the inundated areas for Cases 4L, 4H, 5A, 5B and 5C is included under road raise costs. The volume of riprap at the culverts was computed based on the area to be covered by the riprap blankets and the riprapped preformed scour holes and assuming a one-foot riprap thickness. The unit cost for

riprap of \$40 per cubic yard as supplied by the Corps was assumed to include any filter bedding required beneath the riprap.

#### 4.6 Road Raises

Road raises were divided into three major cost items; embankment fill consisting of soils placed and compacted to raise the road surface and side slopes, surface aggregate and riprap placed on the road embankments.

The volume of embankment fill was estimated using average and area computations. Both the existing road and the raised road were assumed to have four horizontal to one vertical side slopes and a thirty-two foot wide surface. The volume of surface aggregate was computed assuming a four-inch thickness across the entire thirty-two foot wide road surface (see Plate 10).

The unit cost for road embankment fill was estimated to be \$2.50 per cubic yard and the unit cost for surface aggregate was estimated to be \$15 per cubic yard. Both estimates were supplied by the Corps.

The volume of riprap on the road embankments was computed based on the area covered assuming riprap placement from three feet below to three feet above the normal design water surface (vertically) and a one-foot riprap thickness (see Plate 10). The unit cost for riprap of \$40 per cubic yard as supplied by the Corps, was assumed.

#### 4.7 Berms and Culvert Backfill

Costs for the berms adjacent to the drop structures and near Station 40+00 of the channel and for culvert backfill at the

road crossings were computed based on average end area volume computations and the \$2.50 per cubic yard unit cost for embankment fill.

#### 4.8 Lateral Inflow Culverts

The cost for each lateral inflow culvert was based on the assumption that 100 feet of 36-inch RCP would be required at \$50 per foot. The \$5,000 for the RCP was added to the assumed cost of \$3,000 for the drop manhole inlet, resulting in a total estimated cost of \$8,000 for one lateral inflow culvert.

#### 4.9 Pump Stations

Pump station costs were supplied by the Corps for three pumping capacities. The estimated costs for 200, 600, and 1,000 cfs capacities are \$1.61 million, \$4.45 million, and \$6.60 million, respectively.

#### 4.10 Contingencies, Engineering and Design and Supervision and Administration

Contingencies, engineering and design costs, and supervision and administration costs were included as twenty percent, ten percent, and eight percent respectively of the total of the costs of the specific construction items identified in subsections 4.1 to 4.8 above. These percentages were provided by the Corps.

### 5.0 OPERATION

The connecting channel between East Devils Lake and West Stump Lake will be used intermittently to discharge water from the Devils Lake chain of lakes as necessary to achieve desired water levels. The preliminary designs for the connecting channel presented in this



report could be operated in a variety of ways. This section discusses in general terms a potential operating scheme for the channel designs. The operating scheme presented provides for ease of operation and for minimization of impact on the wetlands adjacent to the connecting channel.

#### 5.1 Non-Operational Periods

The channel alignment passes through an area containing natural wetlands. All of the cases would have at least portions of the channel excavated adjacent to the wetlands. Those reaches of the channels, if allowed to drain during periods when no water is being discharged from Devils Lake, would possibly over time dewater the wetlands by the mechanism of groundwater drawdown. To minimize impact to the adjacent wetlands, it is advantageous to maintain a water level in the channel during non-operational periods which is near the natural surface water levels in the adjacent wetlands. To prevent intermixing of lake waters used to fill the channel with the waters in the natural wetlands, the existing wetlands would be separated from the channel by berms. These berms are discussed in Section 5.3. The upper reaches of Cases 4L, 4H, 5A, 5B and 5C inundate currently farmed areas during operation. Inundation of these areas would be maintained at the same levels during non-operational periods, thereby permanently expanding wetland habitat. These new wetlands would be allowed to mix with water pumped from Devils Lake.

One method to maintain the channel full of water would be to place stoplogs at the entrances (and under some circumstances the exits) of the road crossing culverts. The channel reaches could then be pumped full of water from Devils Lake or Stump Lake or allowed to fill naturally from surface runoff and groundwater inflow. The preliminary designs previously presented for the road crossing culverts

include stoplog slots. Access to place the logs could be provided down the 4 horizontal to 1 vertical side slopes of the culvert backfill. The impact of leakage through the stoplogs and/or methods to reduce leakage are beyond the scope of this report.

Slide gates at the upstream end of the culverts at road crossing seven would provide the means for stopping discharge through the connecting channel for Cases 1A, 1B, 1C and 2G. Ceasing of pumping at the pump station immediately upstream of road crossing seven is all that is required to shut down the connecting channel for the other cases.

## 5.2 Start-Up

Start-up of discharges through the channel, assuming it is maintained full as described above, is complicated by the difficulties of removing the submerged stoplogs. One possible solution would be to provide gates on the culvert entrances that could be operated from the road surface. The large gates and apparatus which would be required makes this solution prohibitively expensive.

An alternate, less expensive, solution was incorporated into the preliminary design for the road crossing culverts. A 36-inch reinforced concrete pipe was placed parallel to the larger box culverts under the roads. A flap gate or valve operational from the road could be placed on the 36-inch line much more cheaply than on the box culverts. Prior to start-up of channel operation, the 36-inch pipes would be opened and the channel would be drained sufficiently to allow access to the box culvert stoplogs. The addition of the thirty-six inch culvert also provides potential for some additional capacity during operation of the channel.

For the completely gravity flow cases (1A, 1B, 1C and 2G), the slide gates at the upstream end of the connecting channel would be opened at a controlled rate to prevent excessive channel velocities during start-up. Pumping rates would be increased gradually at start up for the other cases to prevent excessive channel velocities.

### 5.3 Operational Periods

During operational periods, the design water surface in the channel is below the natural wetlands water level, creating the potential to dewater the adjacent wetlands. To prevent uncontrolled local surface inflow from the wetlands during channel operation, berms constructed of select spoil material excavated from the channel would be placed between the channel and the wetlands. Select spoil would consist of portions of the material excavated from the channel which are low in organic content and are most suitable for berm construction. The berms are shown on the location maps in Appendix A and the appropriate cross sections in Appendix C.

Nothing is proposed here to limit the flow of groundwater seepage from the wetlands into the channel during channel operation. The cases with the lower design operating water surface elevations in relation to the adjacent wetland water surface elevations would have the greatest amount of groundwater seepage because of the steeper groundwater gradient. Dewatering of the wetlands caused by groundwater seepage into the channel could have detrimental impacts on the adjacent wetlands, particularly during periods of prolonged channel operation.

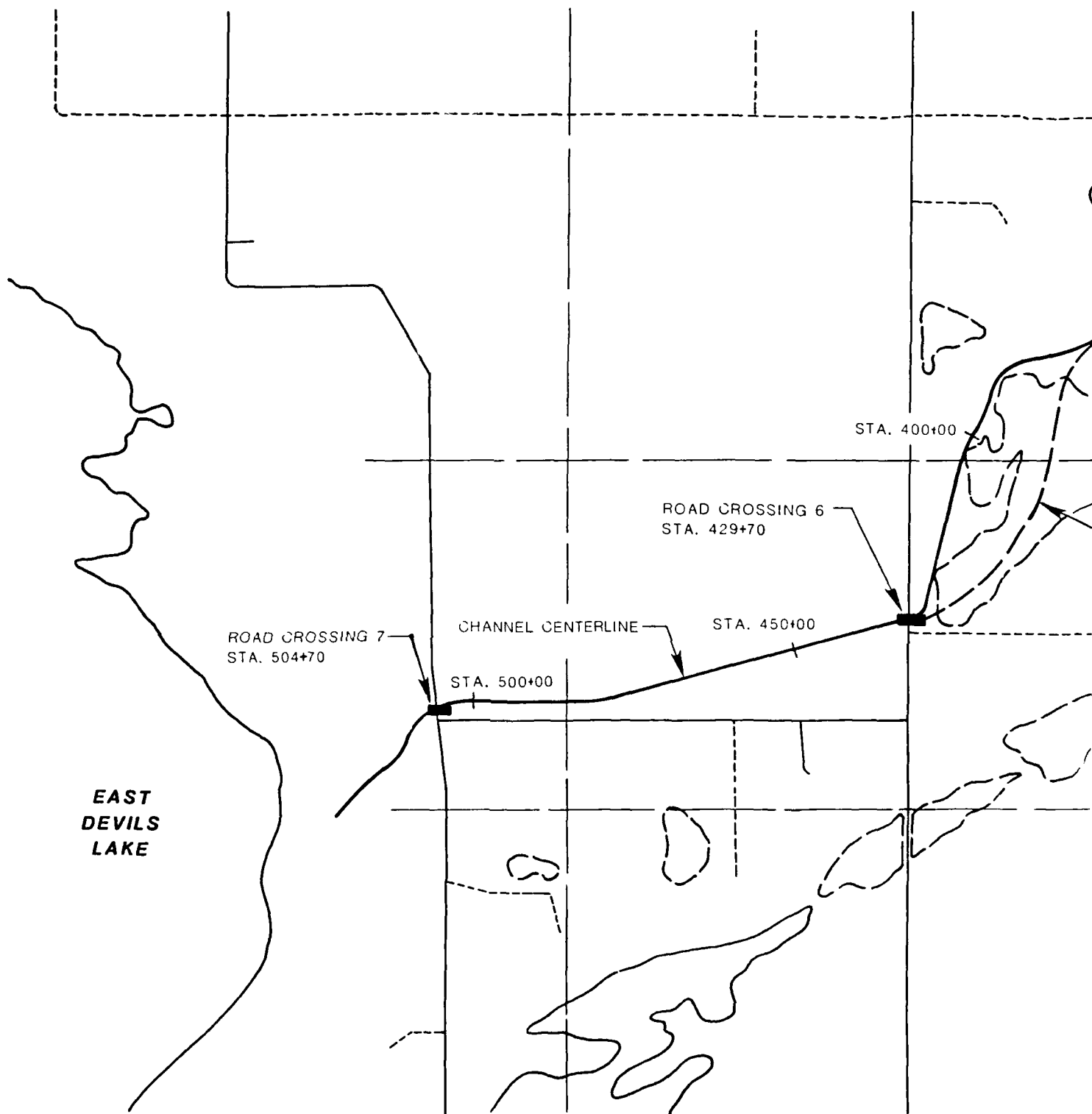
Cases 4H, 4L, 5A, 5B, and 5C would result in inundation of lowland areas surrounding the channel alignment at the upstream end of the channel during channel operations. The inundated areas are indicated on the location maps in

Appendix A. The inundation of these lowland areas would expand wetland habitat. It is proposed to maintain the inundated areas at the same water level even during non-operational periods of the connecting channel.

#### REFERENCES

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- "Drainage Manual", State of Minnesota Department of Highways (Highway Department Manual, No. 5-294).
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- ETL1110-2-120, "Addition Guidance for Riprap Channel Protection", Department of the Army, Office of the Chief of Engineers, May, 1971.
- "Hydraulic Design Criteria", U.S. Army Engineer Waterways Experimental Station, Vicksburg, Mississippi (Volumes 1 and 2, January, 1977).
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- "Open Channel Flow", by F.M. Henderson, 1966.
- Reconnaissance Report, Devils Lake Basin, N.D., November, 1984.
- "Soil and Water Conservation Engineering", by Glenn O. Schwab, Richard F. Frevert, Talcott W. Edmister and Kenneth K. Barnes (2nd edition, 1966).
- "Working Papers on Screening of Outlet Alternatives from Devils Lake to the Sheyenne River, N.D.", Draft, U.S. Army Corps of Engineers, St. Paul District, November, 1985.

## PLATES



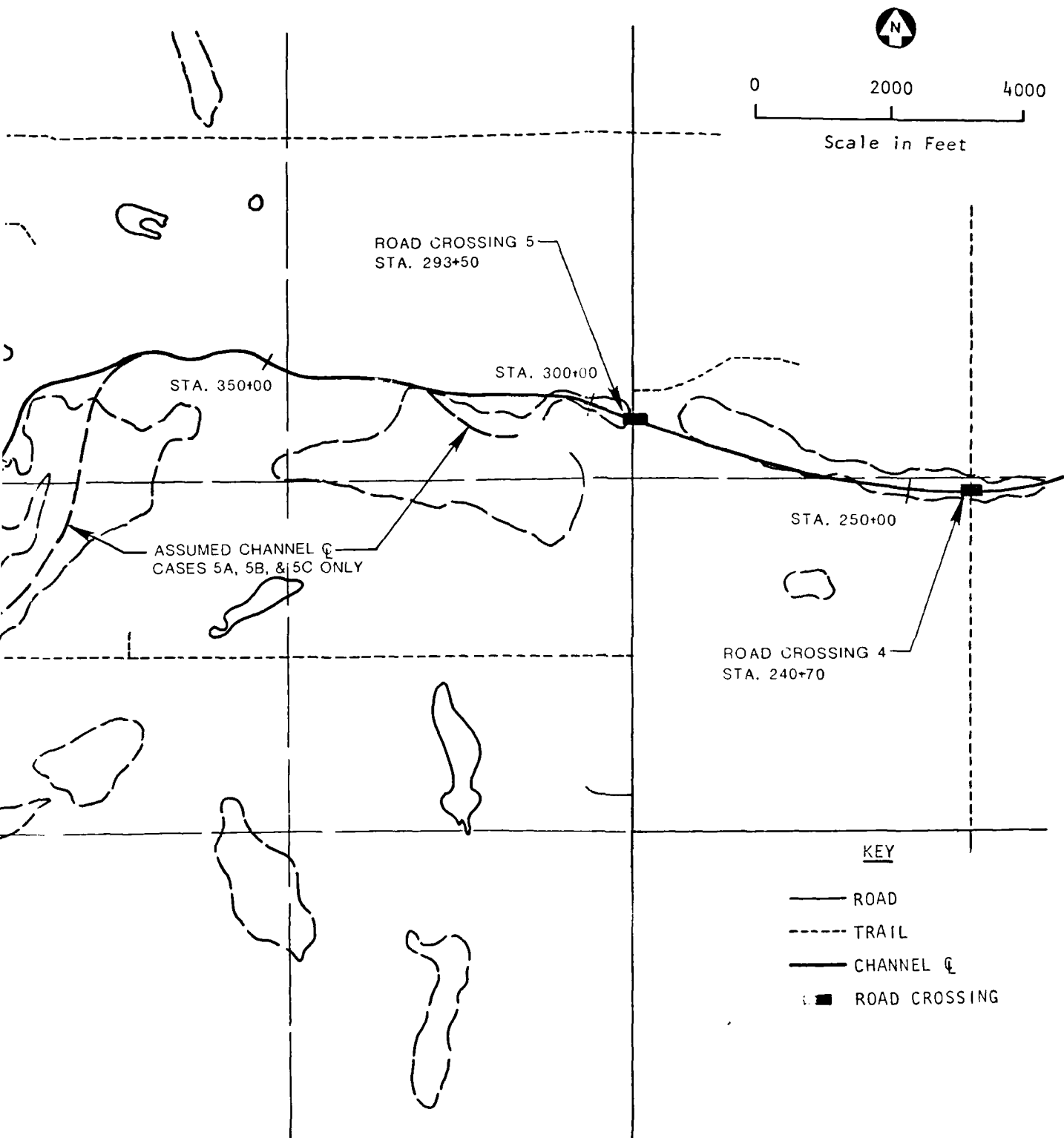
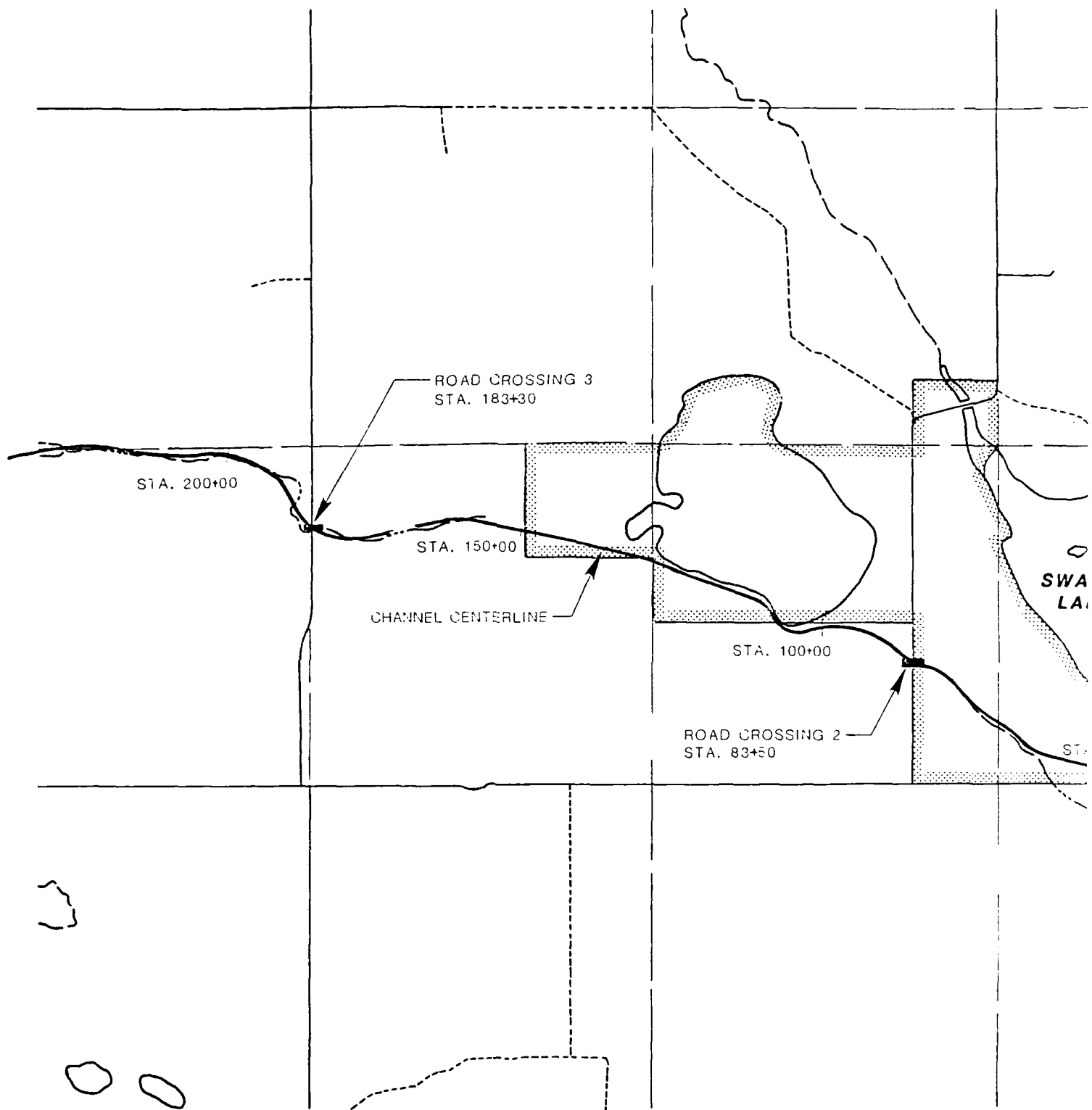


PLATE 1  
CHANNEL ALIGNMENT





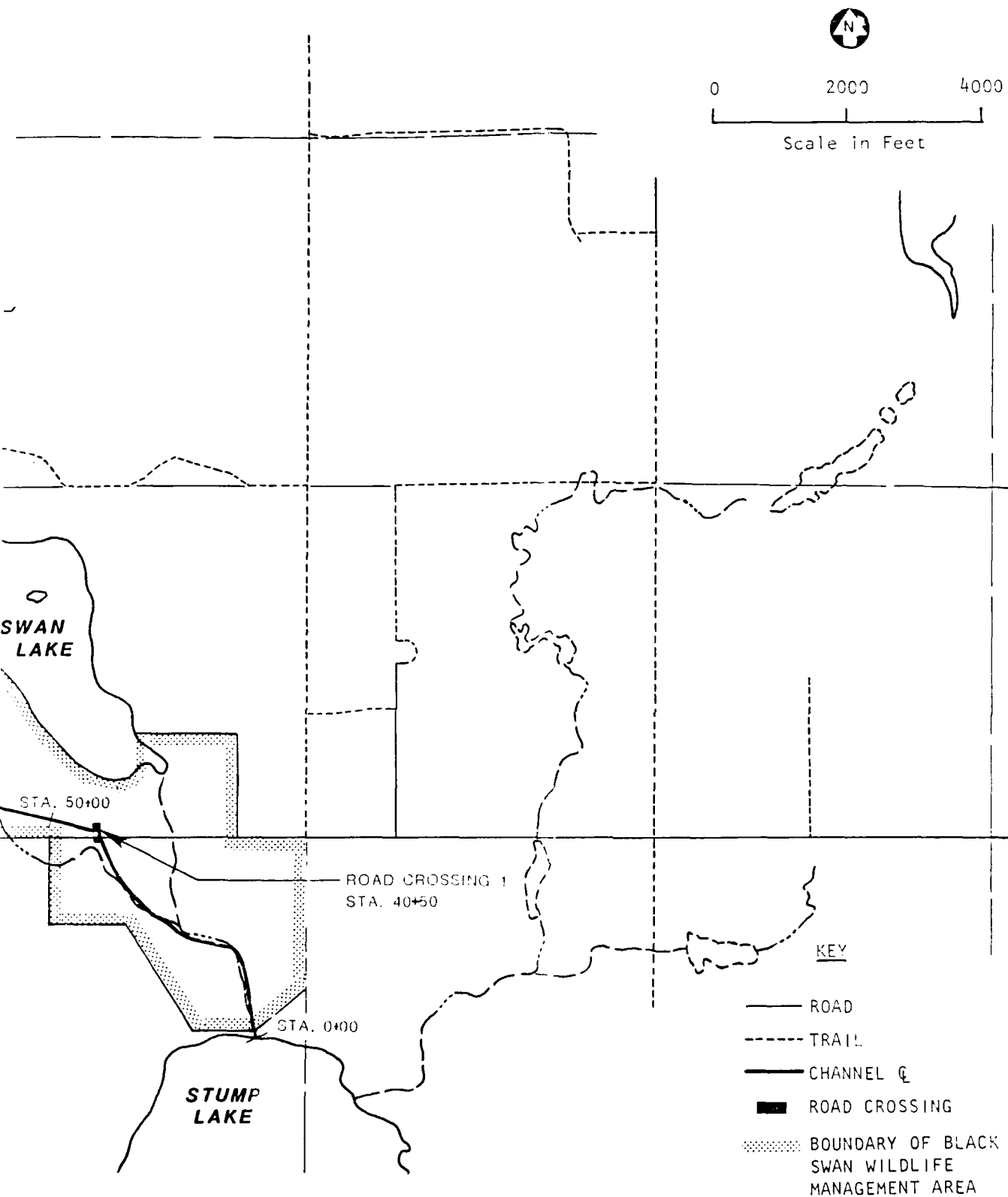


PLATE 2  
CHANNEL ALIGNMENT

2

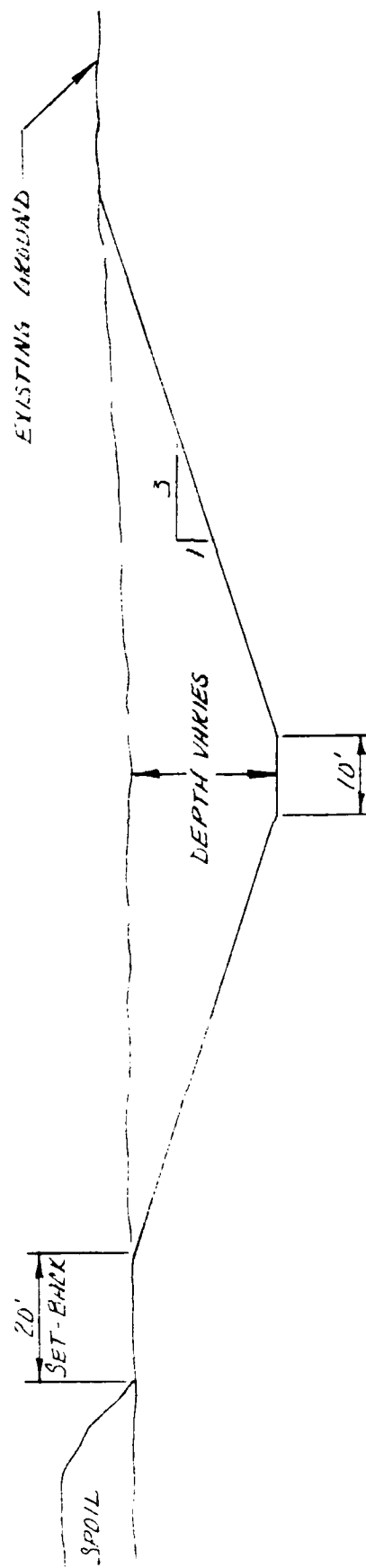


PLATE 3

TYPICAL DRAIN CHANNEL SECTION

SCALE 1" = 20'

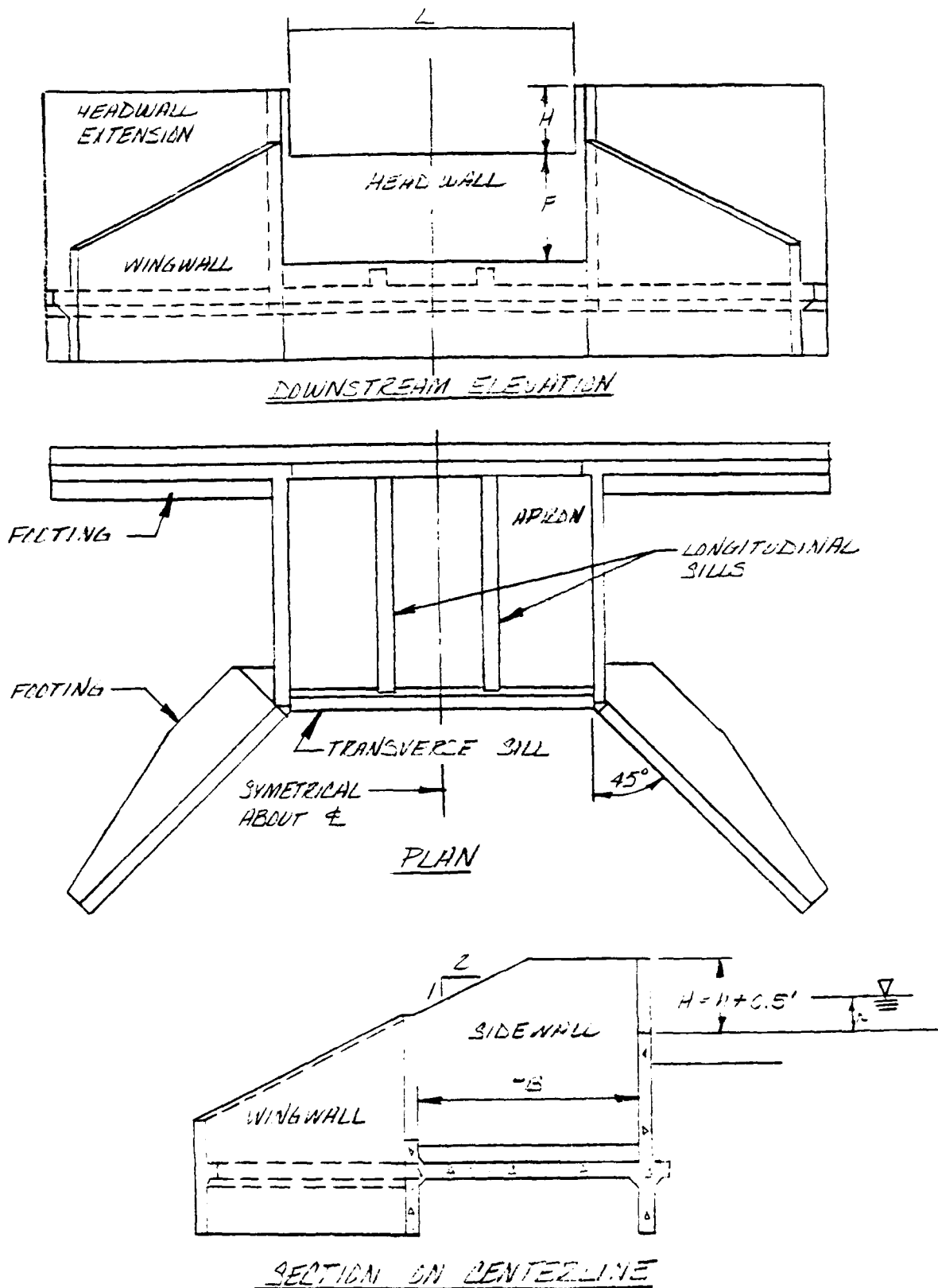
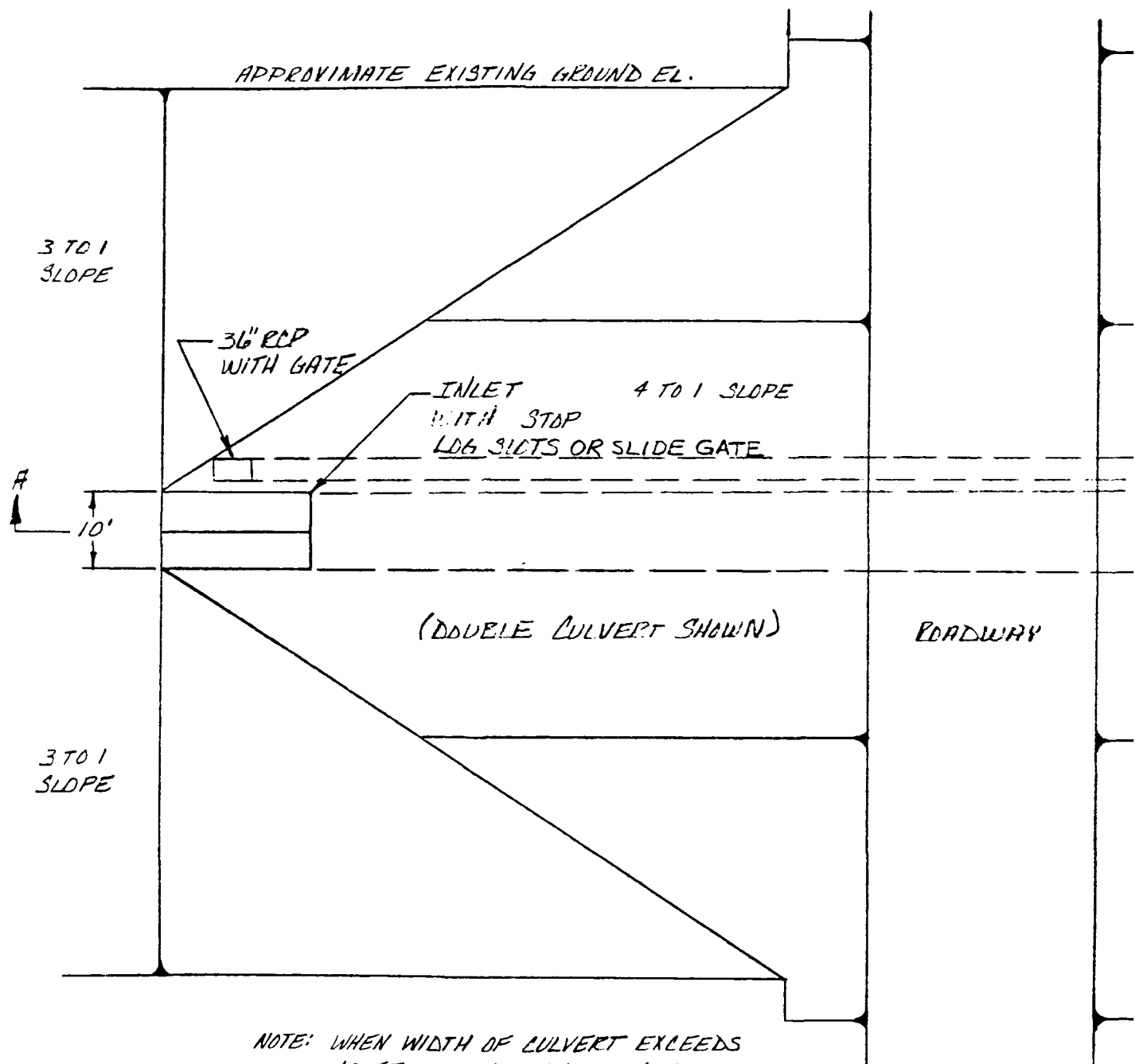
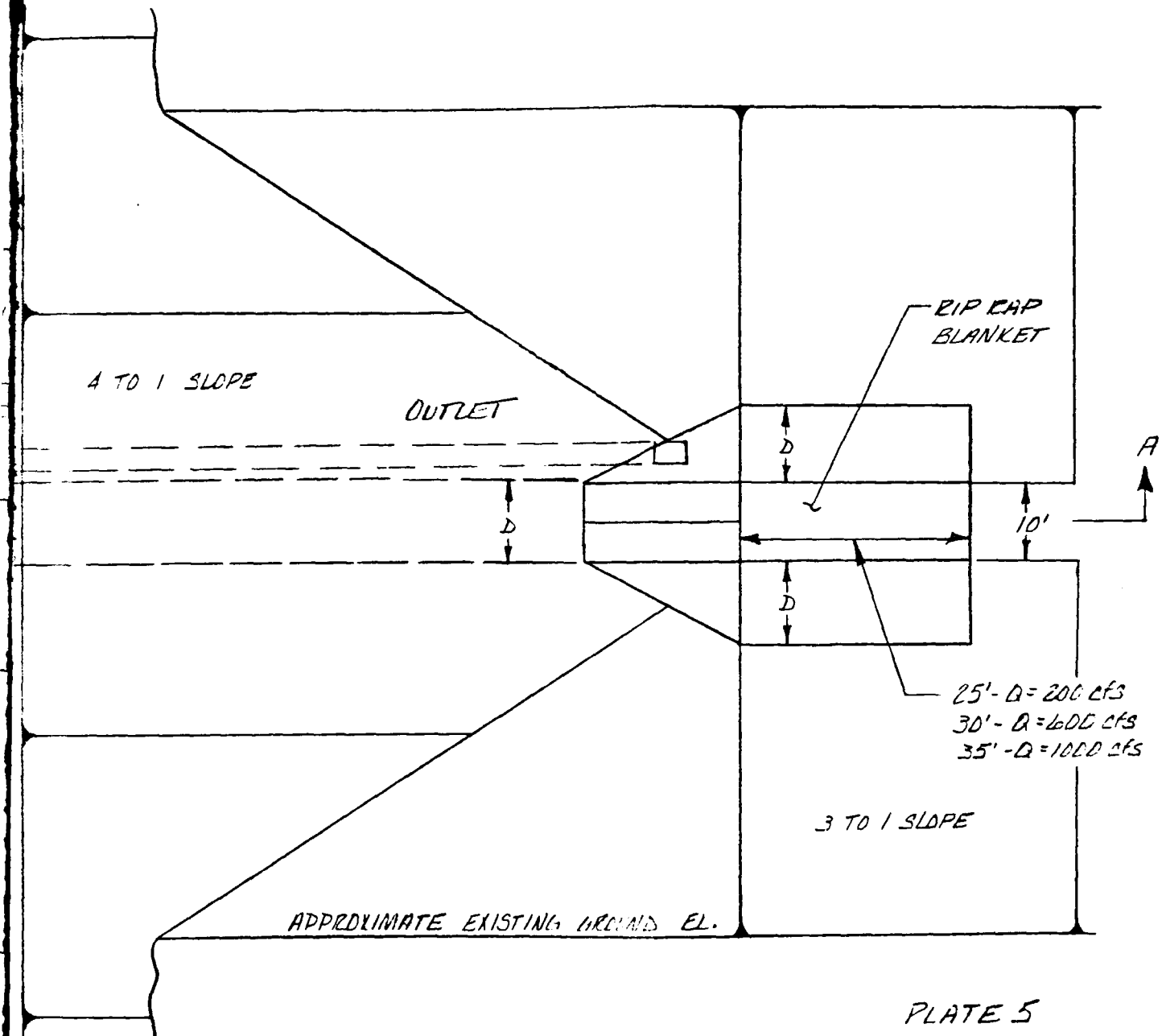


PLATE 4  
 TYPICAL DAM STRUCTURE  
 DERIVED FROM SLE (SLE 67)



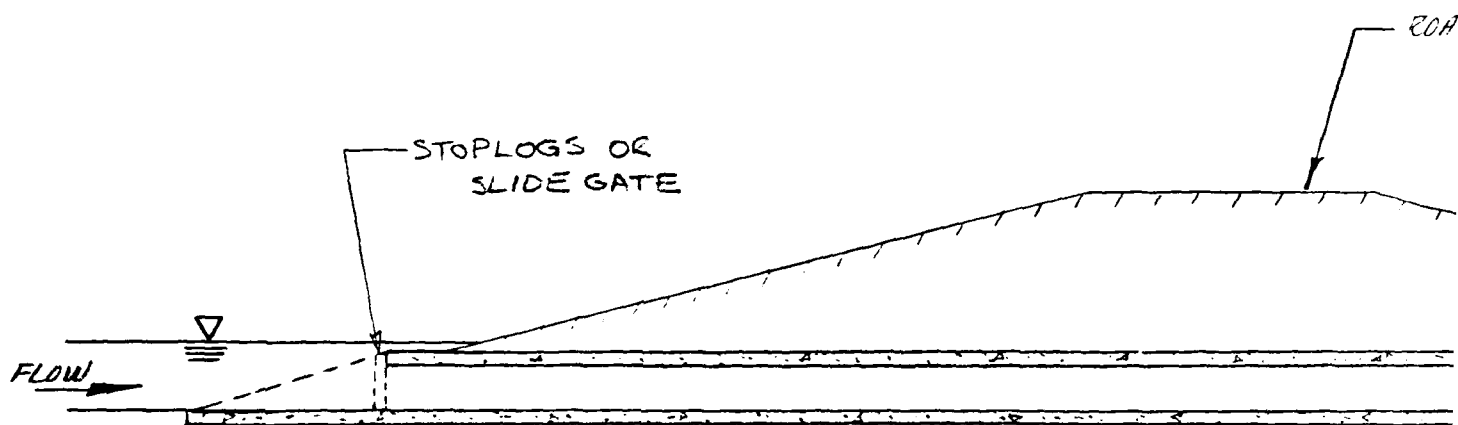
NOTE: WHEN WIDTH OF CULVERT EXCEEDS 10 FT. - 100' TRANSITION TO 10' WIDE CHANNEL IS ASSUMED BOTH UPSTREAM AND DOWNSTREAM.  
SEE PLATE 6 FOR SECTION A-A

PLAN  
SCALE 1"



TYPICAL FLOOD CROSSINGS WITH  
LOW HEAD LOSS

AN  
1" = 20'



SECTION A

SCALE 1" =

ROAD SURFACE

18"  
THK RIPRAVE  
(D<sub>50</sub> = 6")

FLOW

25' - Q = 200 cfs  
30' - Q = 600 cfs  
35' - Q = 1,000 cfs.

SECTION A-A (FROM PLATE 5)

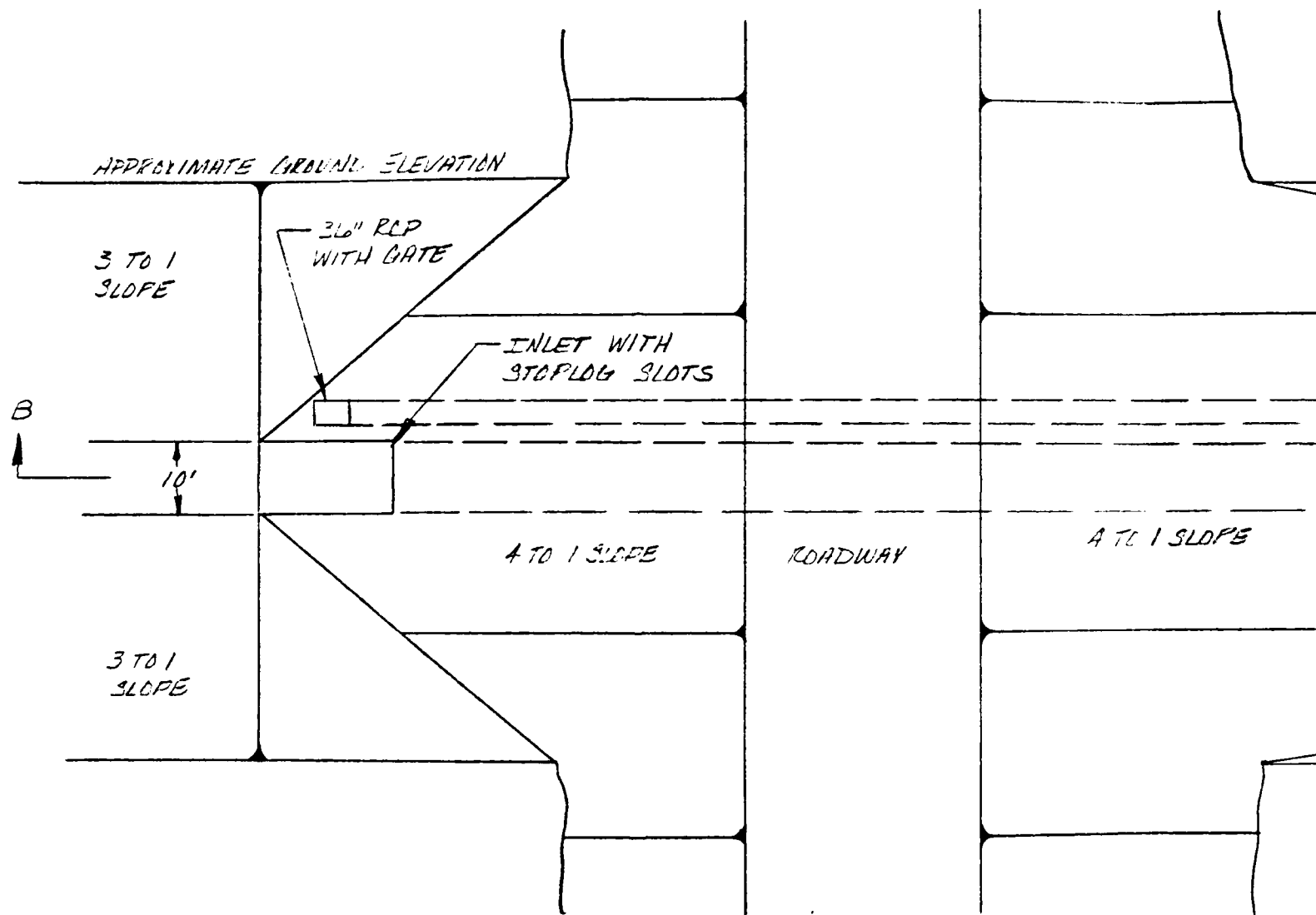
1" = 20'

PLATE 6

TYPICAL ROAD CROSSING WITH  
LOW HEAD LOSS

2





NOTE: WHEN WIDTH OF CULVERT, OR PREFORMED SCOUR HOLE EXCEEDS 10' - 100' TRANSITION TO 10' WIDE CHANNEL IS ASSUMED BOTH UPSTREAM AND DOWNSTREAM.

SEE PLATE 8 FOR SECTION B-B

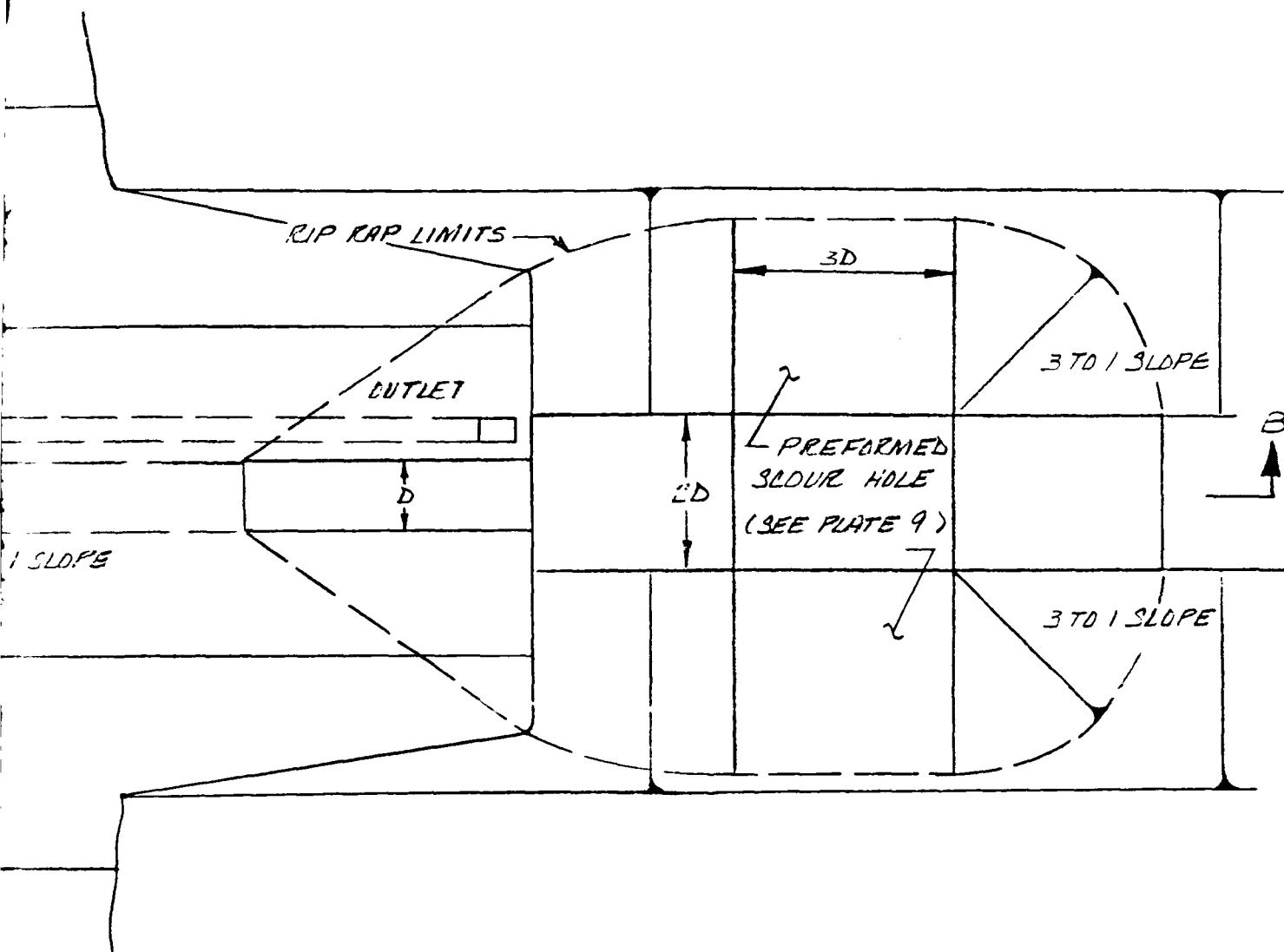
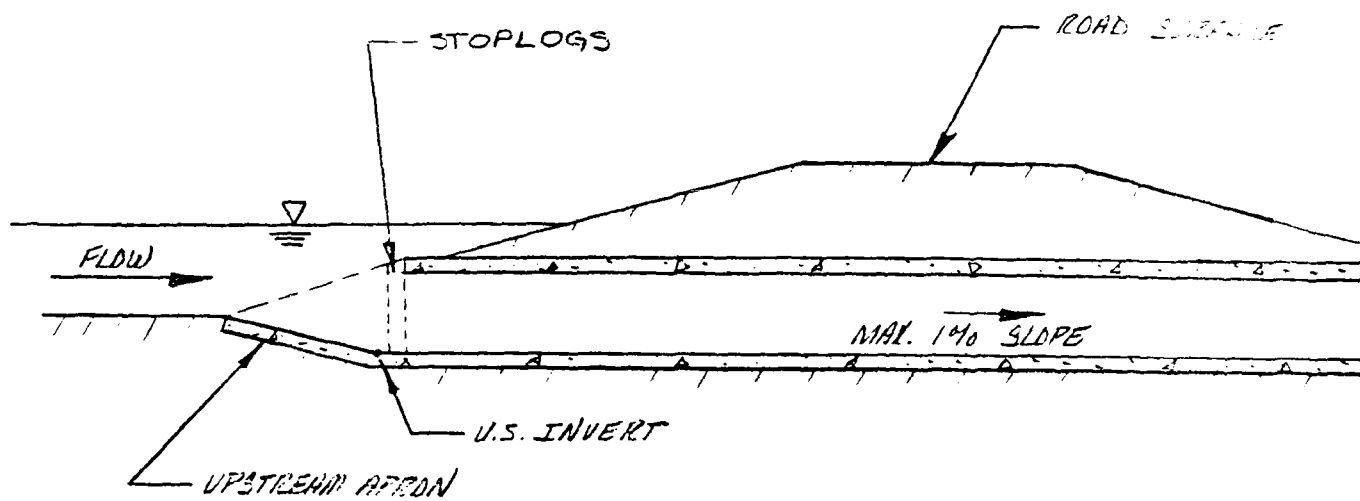
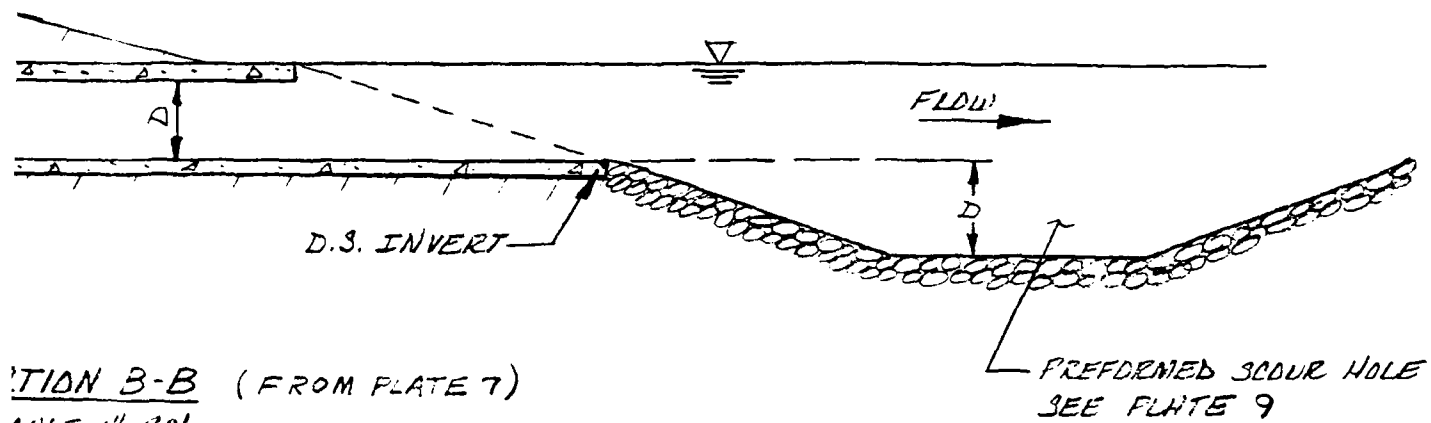


PLATE 9  
TYPICAL ROAD CROSSING WITH  
HIGH HEAD LOSS



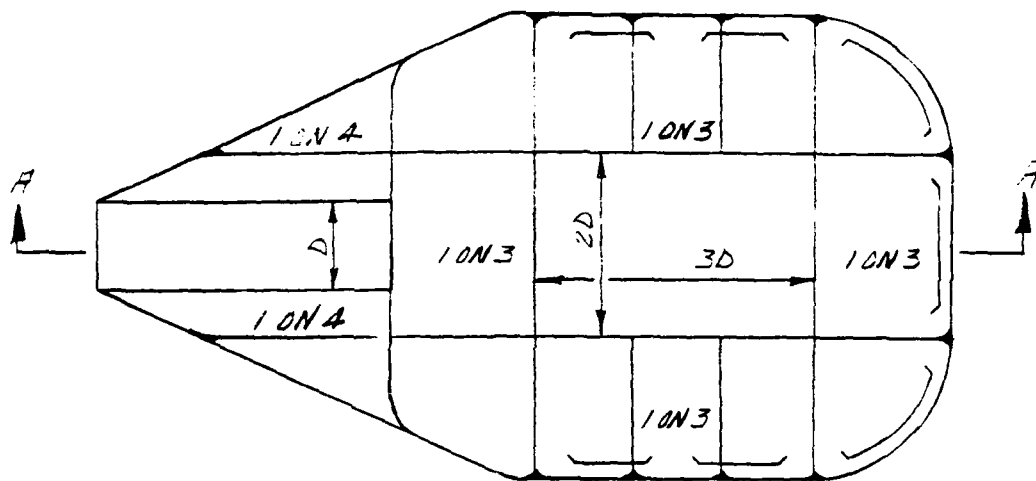
SECTION 2  
SCALE 1" = 10'

2E

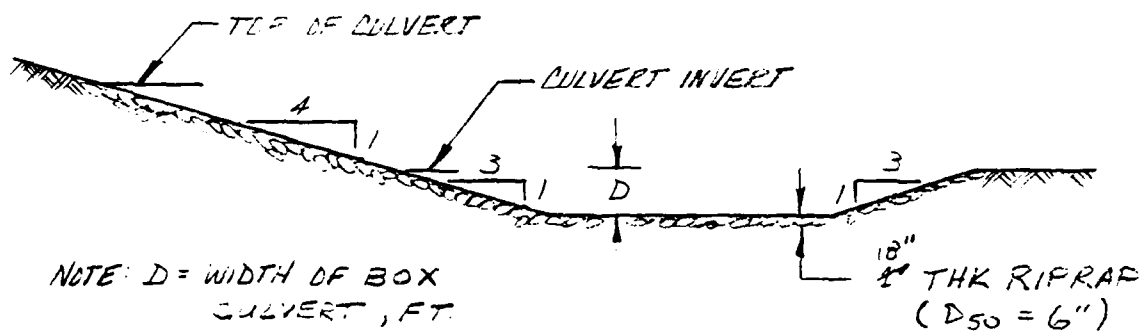


SECTION B-B (FROM PLATE 7)  
SCALE 1" = 20'

PLATE 8  
TYPICAL ROAD CROSSING WITH  
HIGH HEAD LOSS



PLAN



SECTION A-A  
NO SCALE

PLATE 9  
TYPICAL CULVERT OUTLET  
PREFORMED SAND P. HOLE

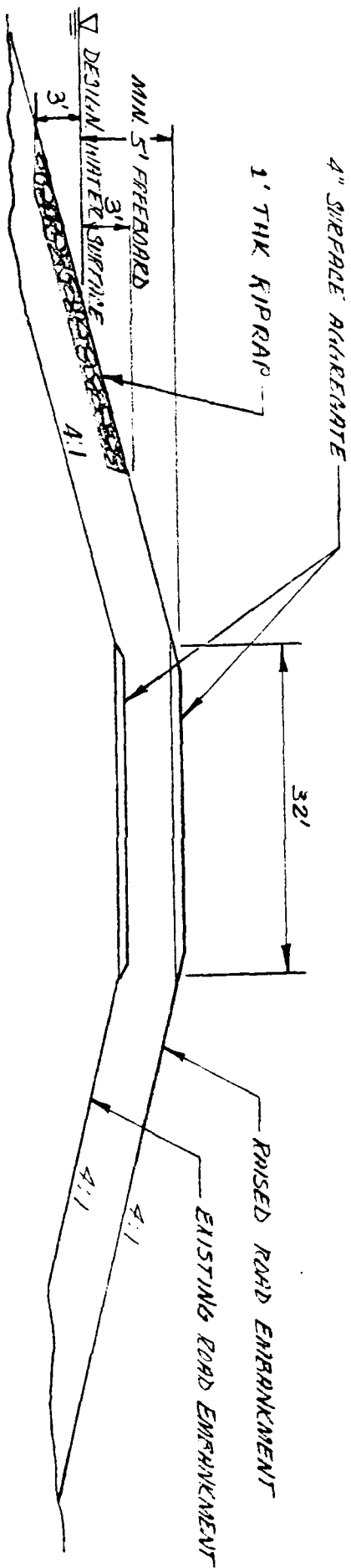
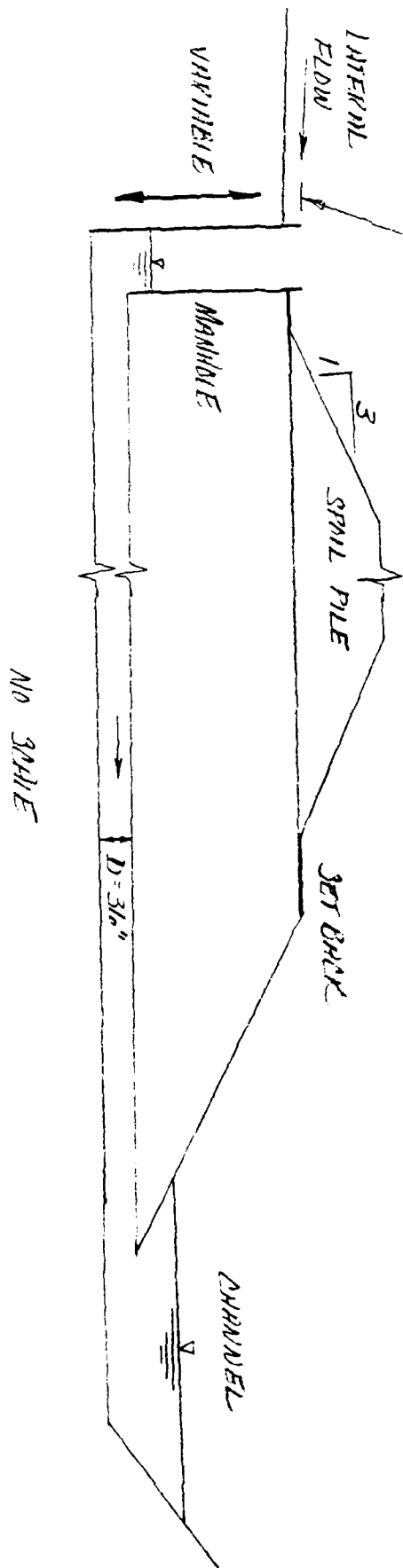


PLATE 10

TYPICAL CROSS SECTION  
NO SCALE

INLET ELEVATION SET TO MAINTAIN ADJACENT  
WETLANDS SURFACE WATER ELEVATIONS  
AT DESIRED LEVEL

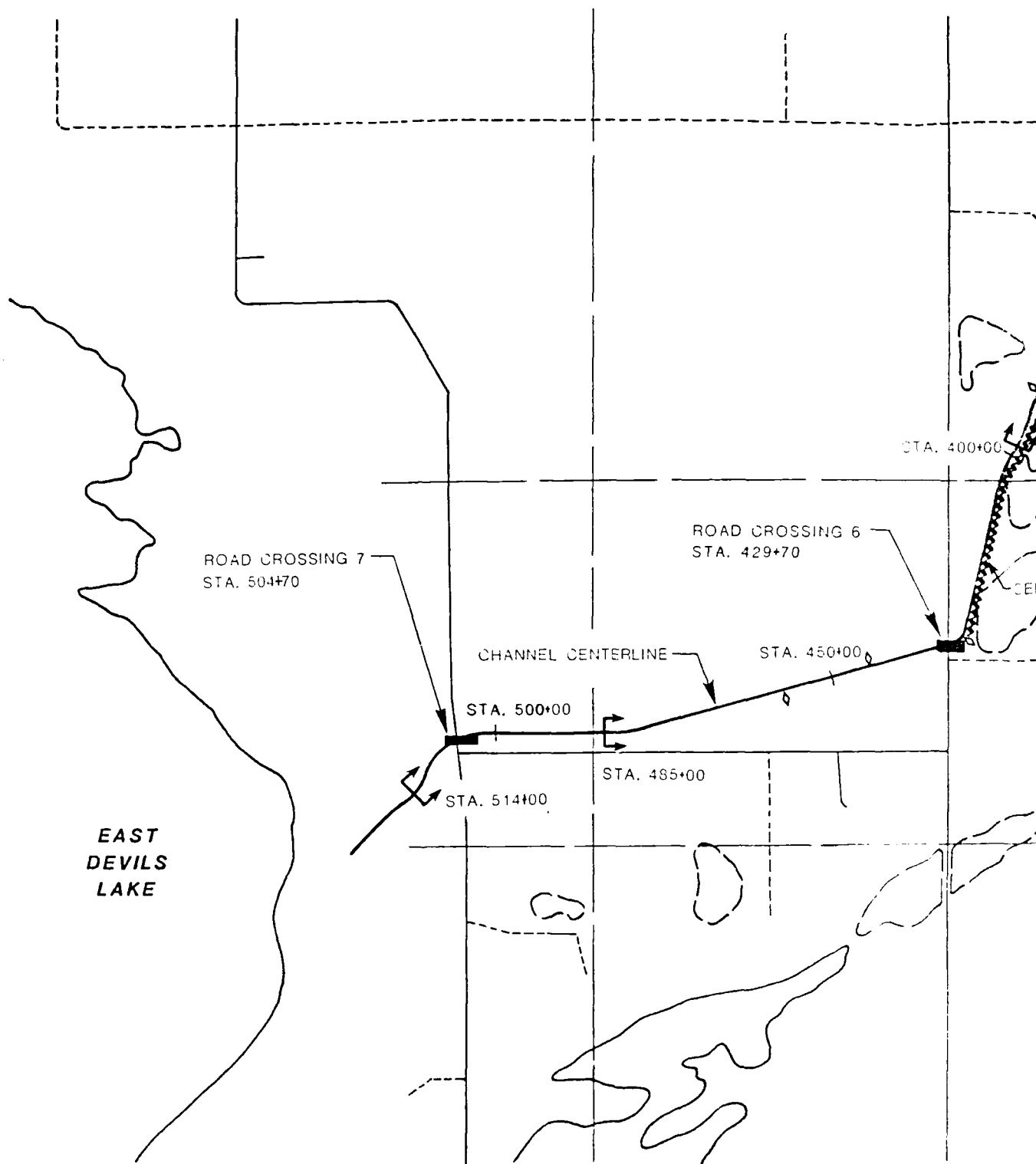


NO SPILL

FIGURE 11  
TYPICAL CROSS SECTION  
OF LATERAL INLET FOR WEIR

**APPENDIX A**  
LOCATION MAPS





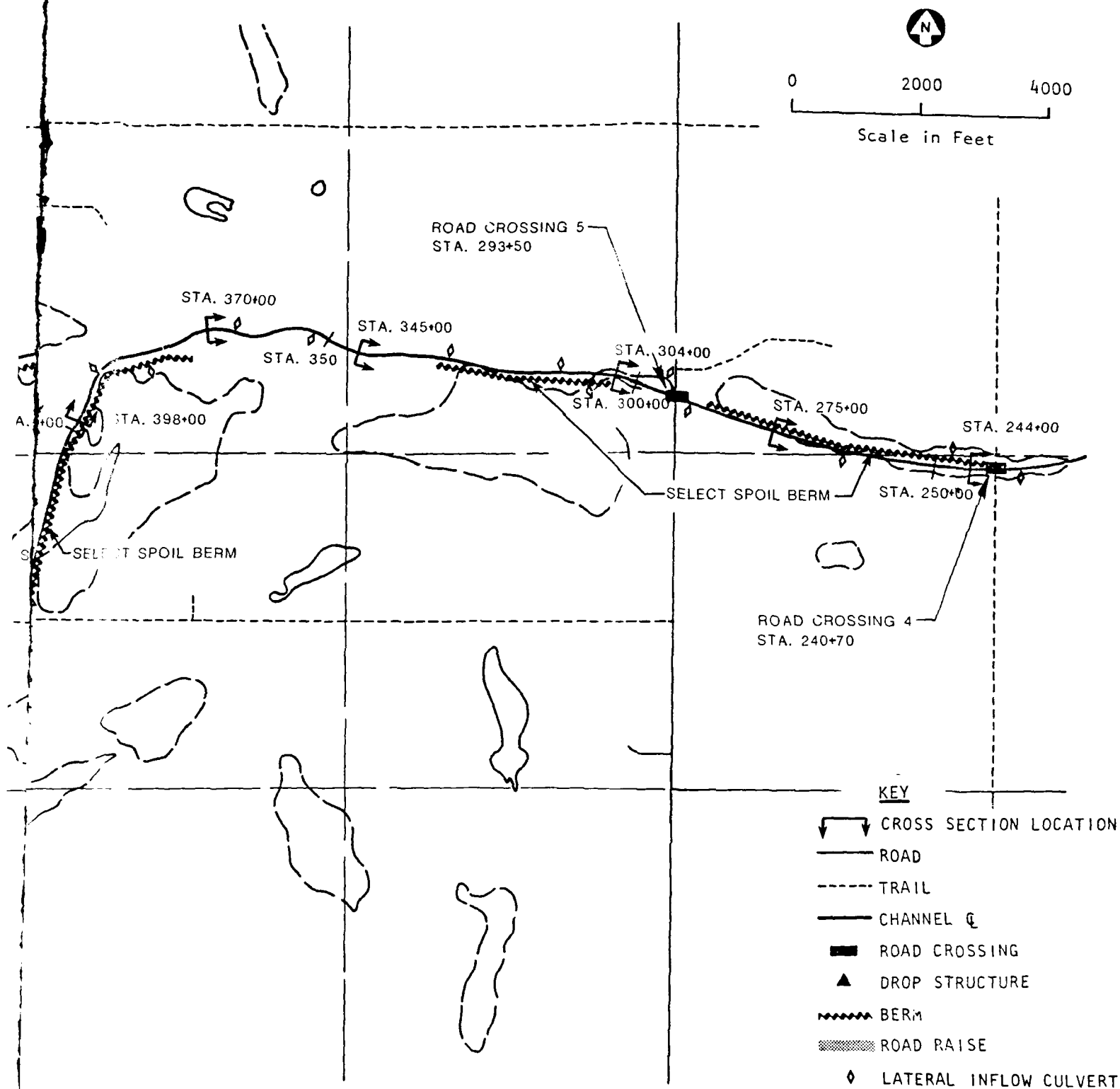
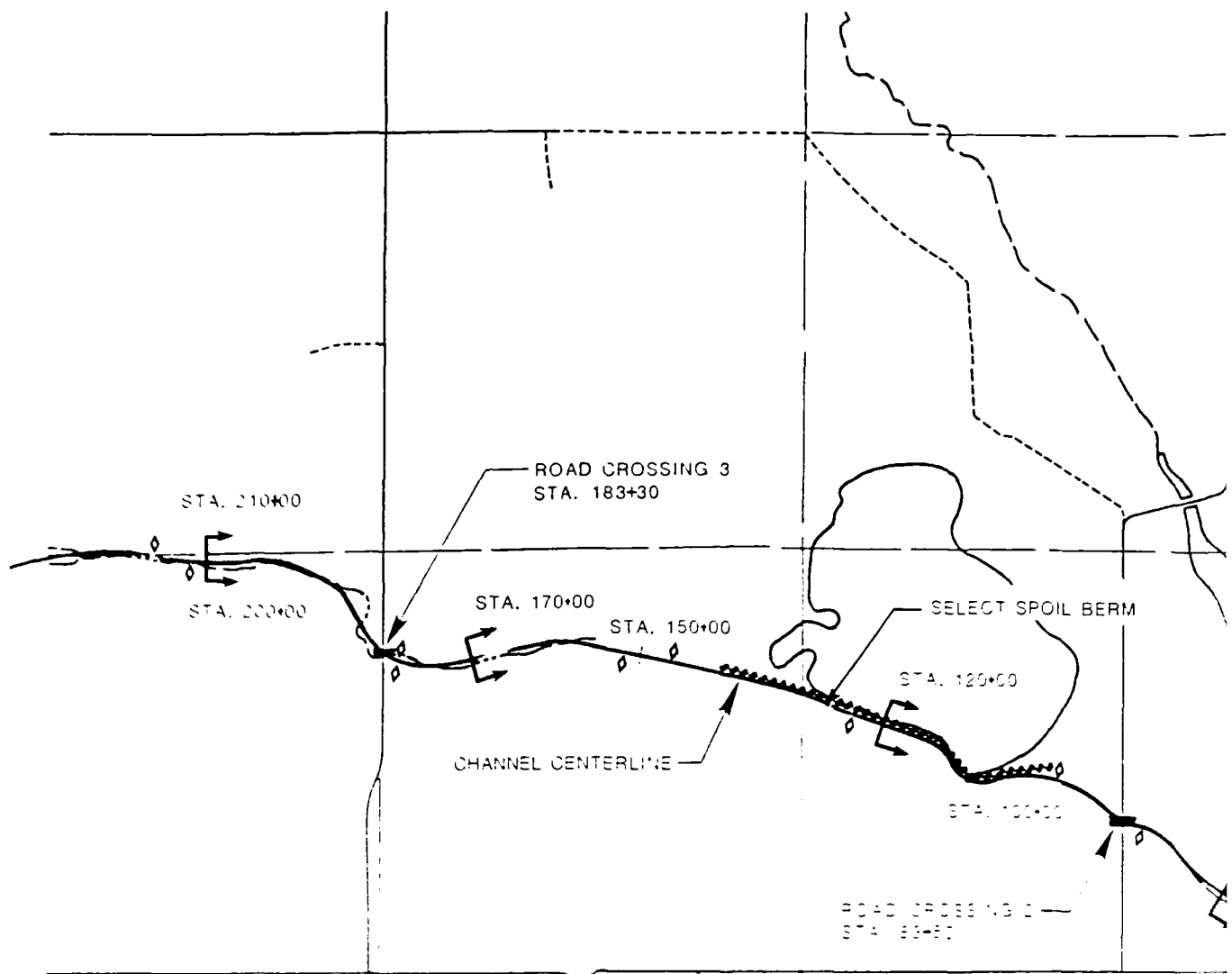


PLATE A-1  
LOCATION MAP  
CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
CASES 1A, 1B, 1C, & 2G





0 2000 4000

Scale in Feet

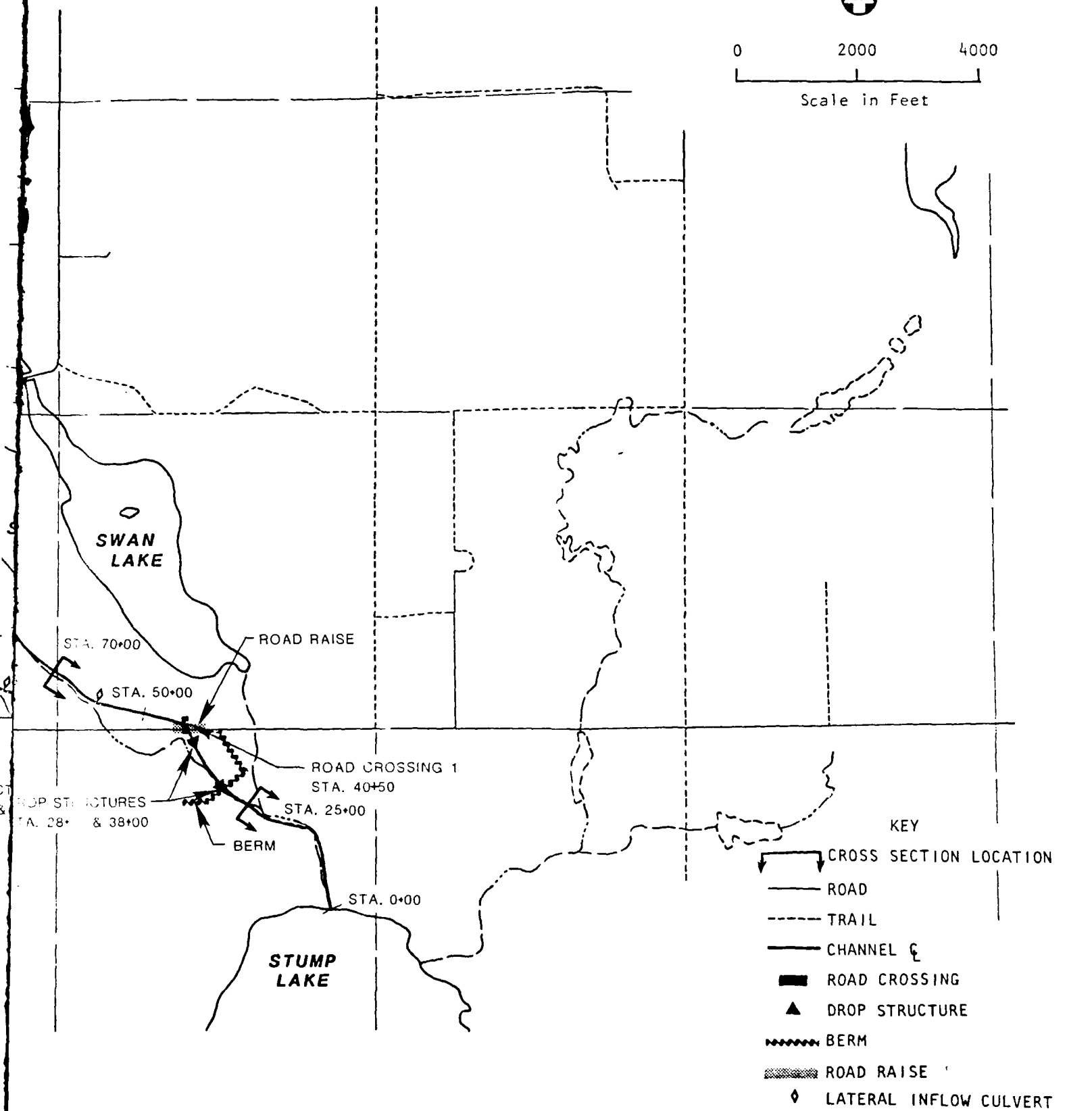
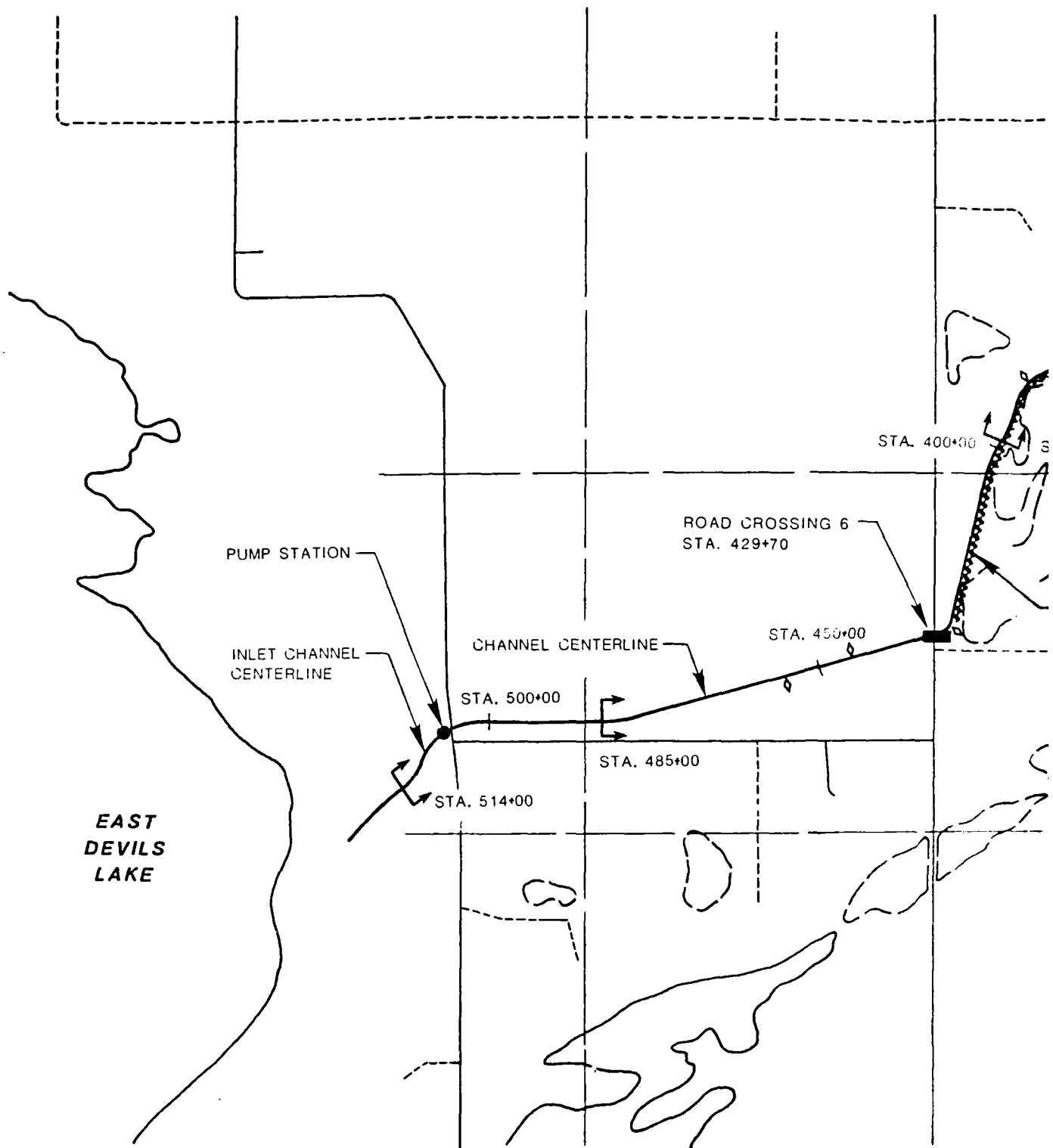


PLATE A-2

LOCATION MAP  
CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
CASES 1A, 1B, 1C & 2G



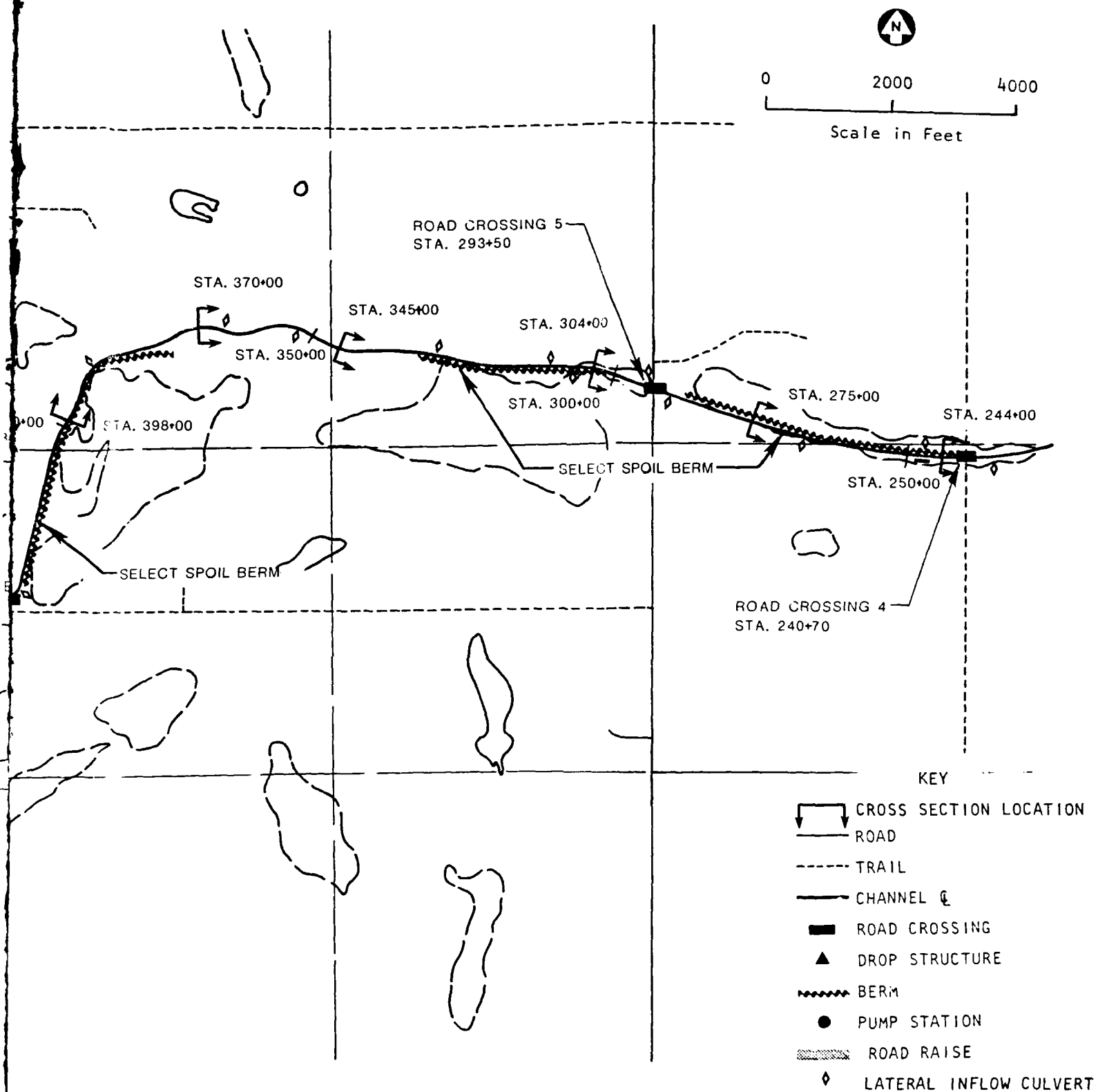
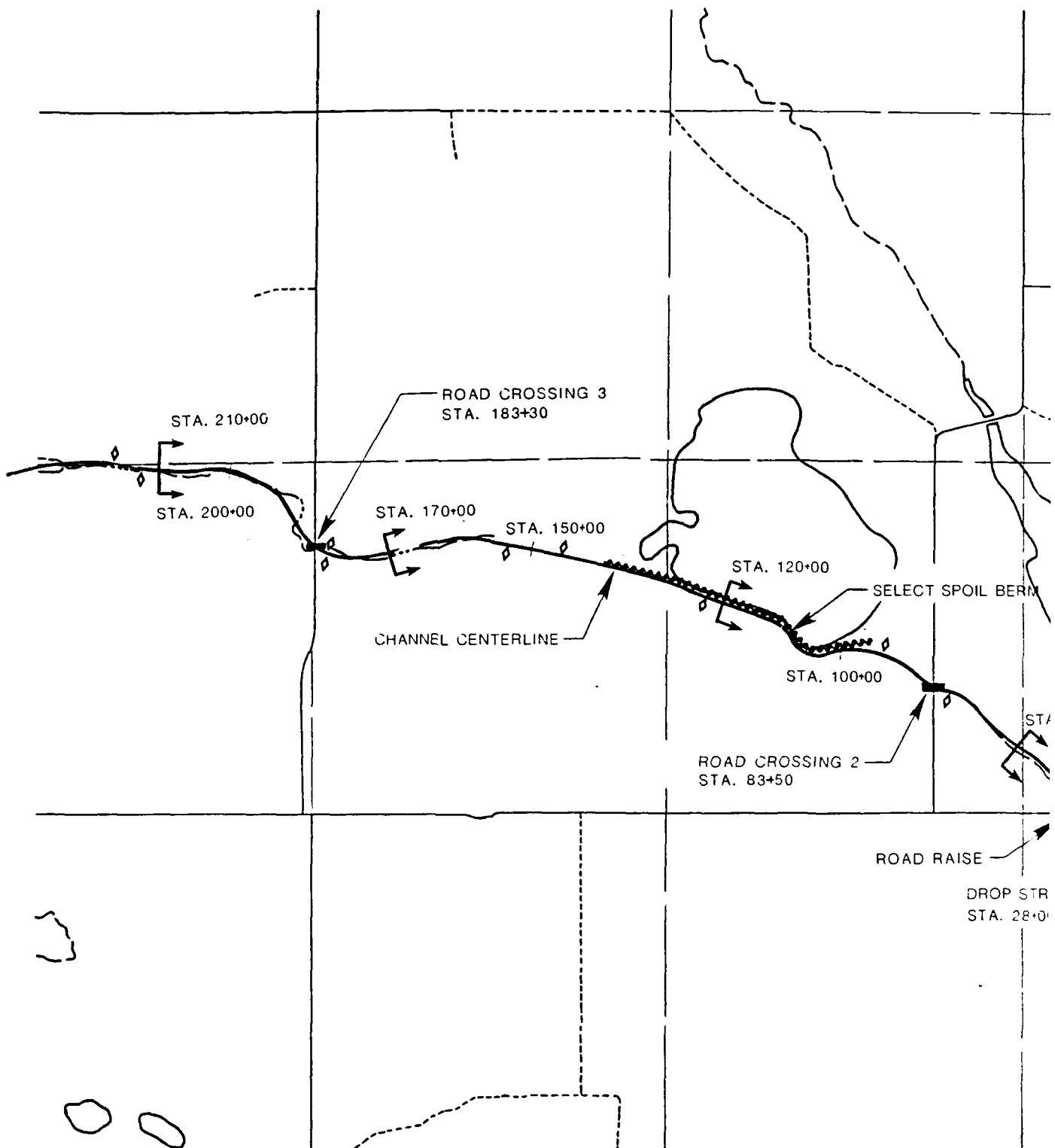


PLATE A-3  
 LOCATION MAP  
 CONNECTING CHANNEL  
 EAST DEVILS LAKE TO WEST STUMP LAKE  
 CASES 2P, 3A, 3B, & 3C





0 2000 4000

Scale in Feet

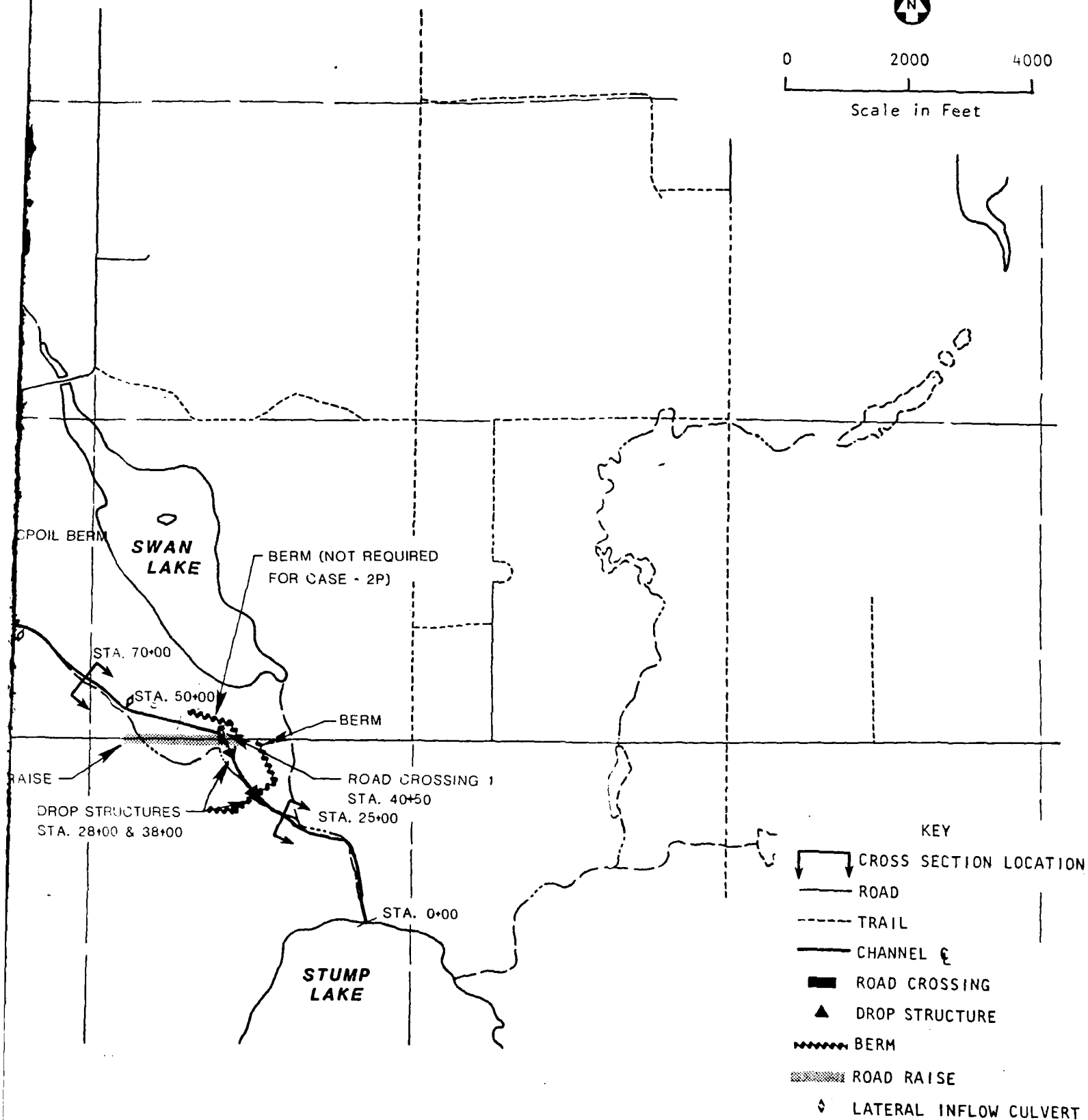
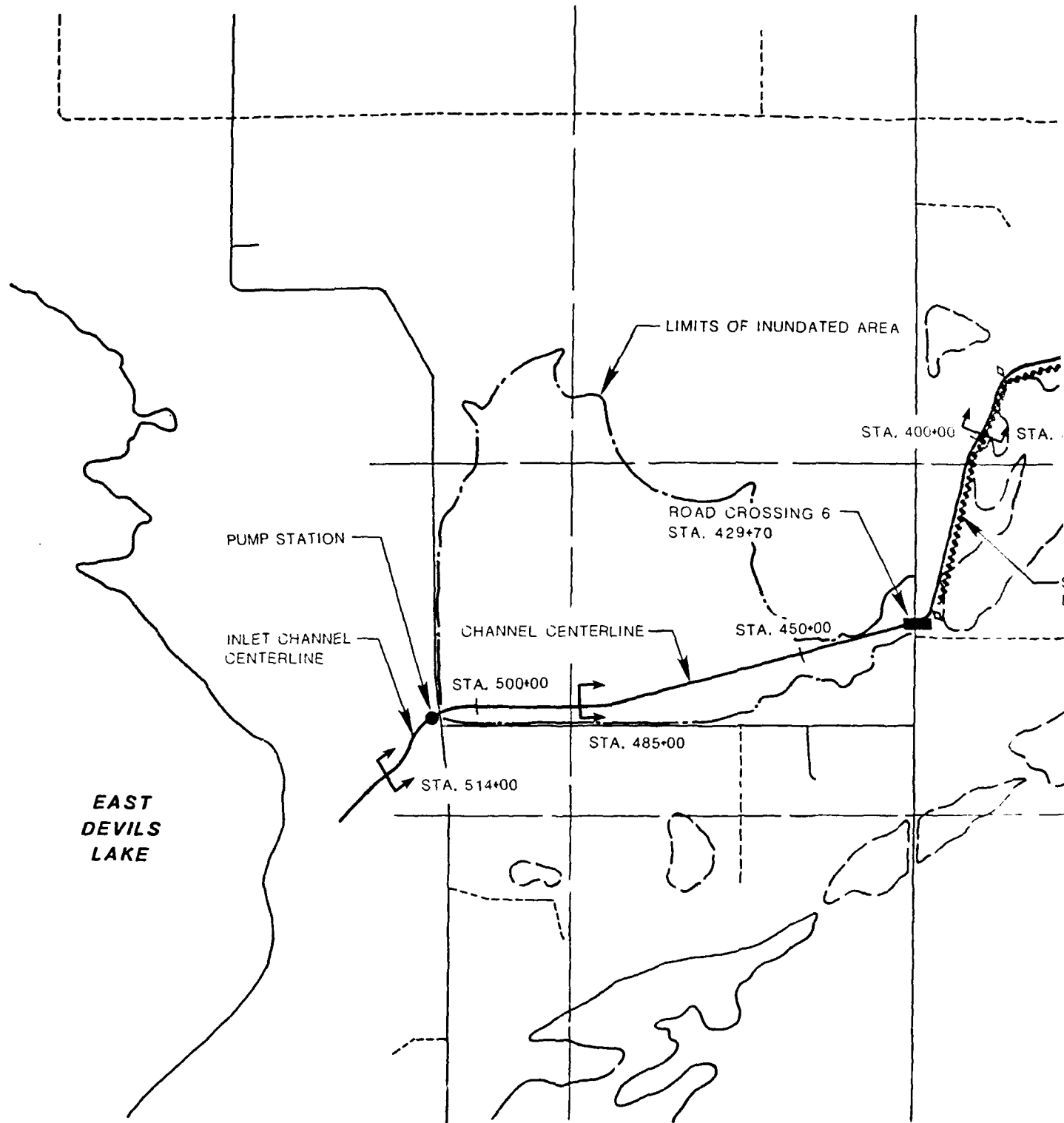


PLATE A-4  
LOCATION MAP  
CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
CASES 2P, 3A, 3B, & 3C





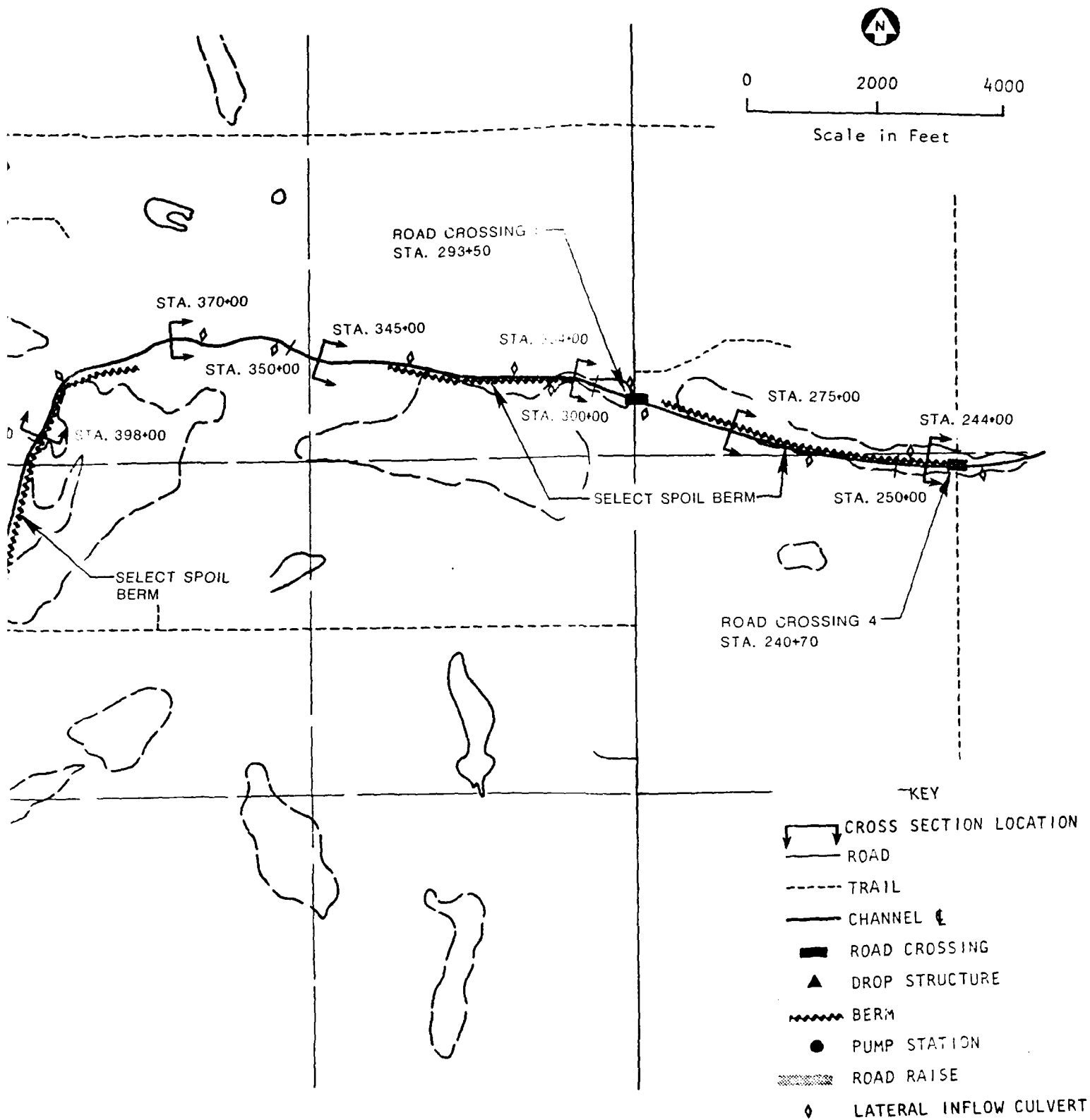
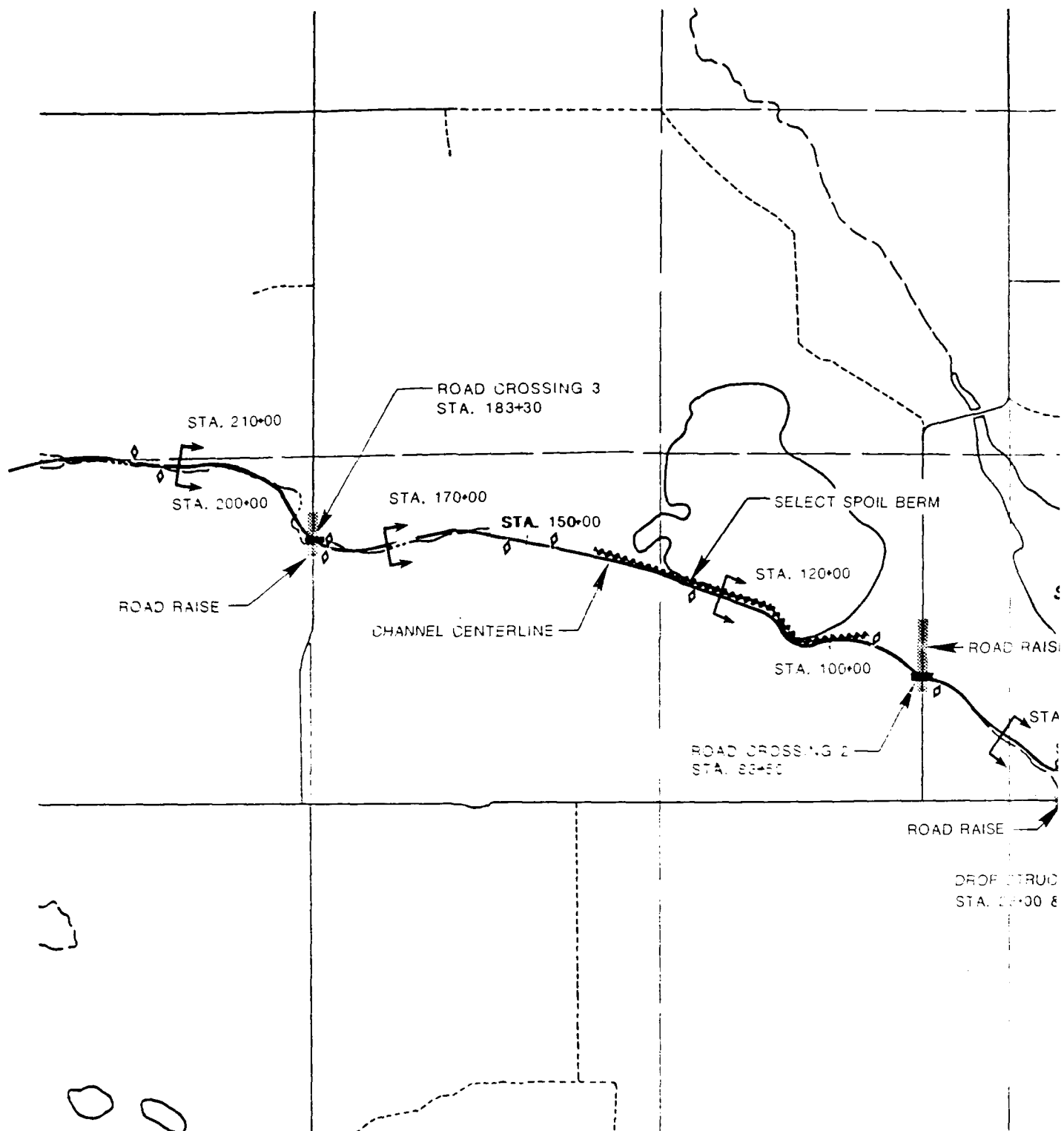
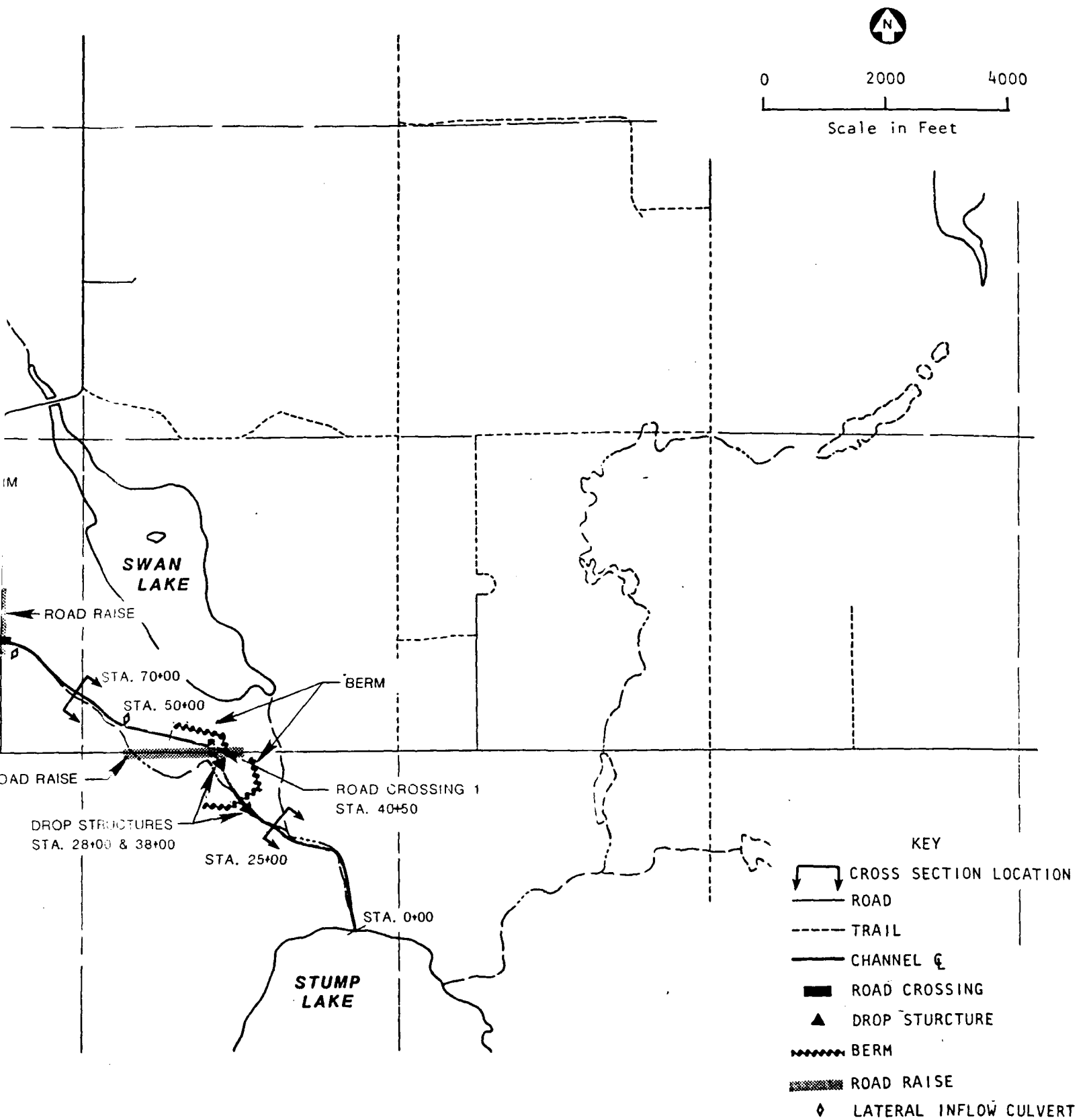
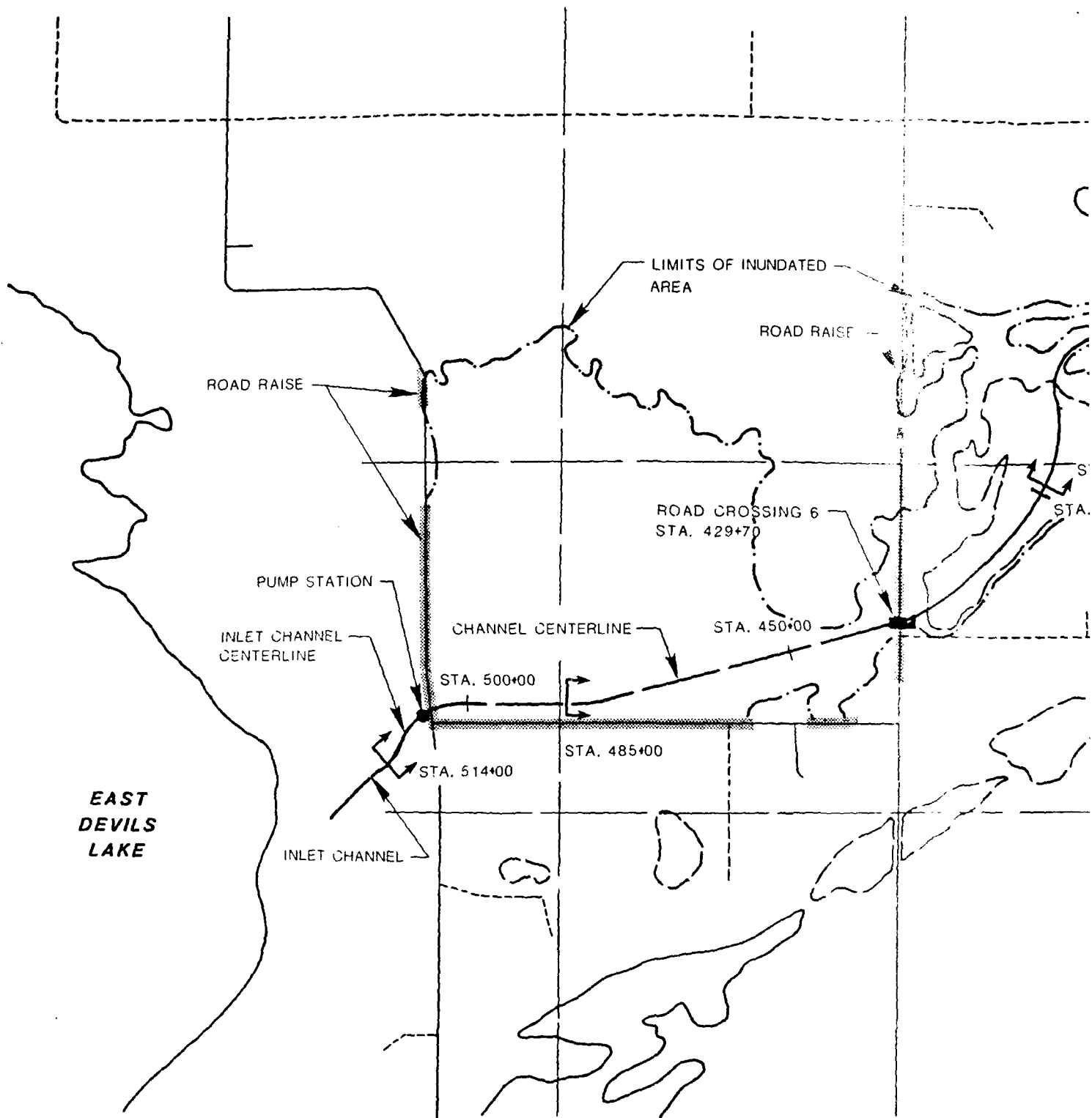


PLATE A-5  
LOCATION MAP  
CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
CASES 4H & 4L





**PLATE A-6**  
**LOCATION MAP**  
**CONNECTING CHANNEL**  
**EAST DEVILS LAKE TO WEST STUMP LAKE**  
**CASES 4L & 4H**



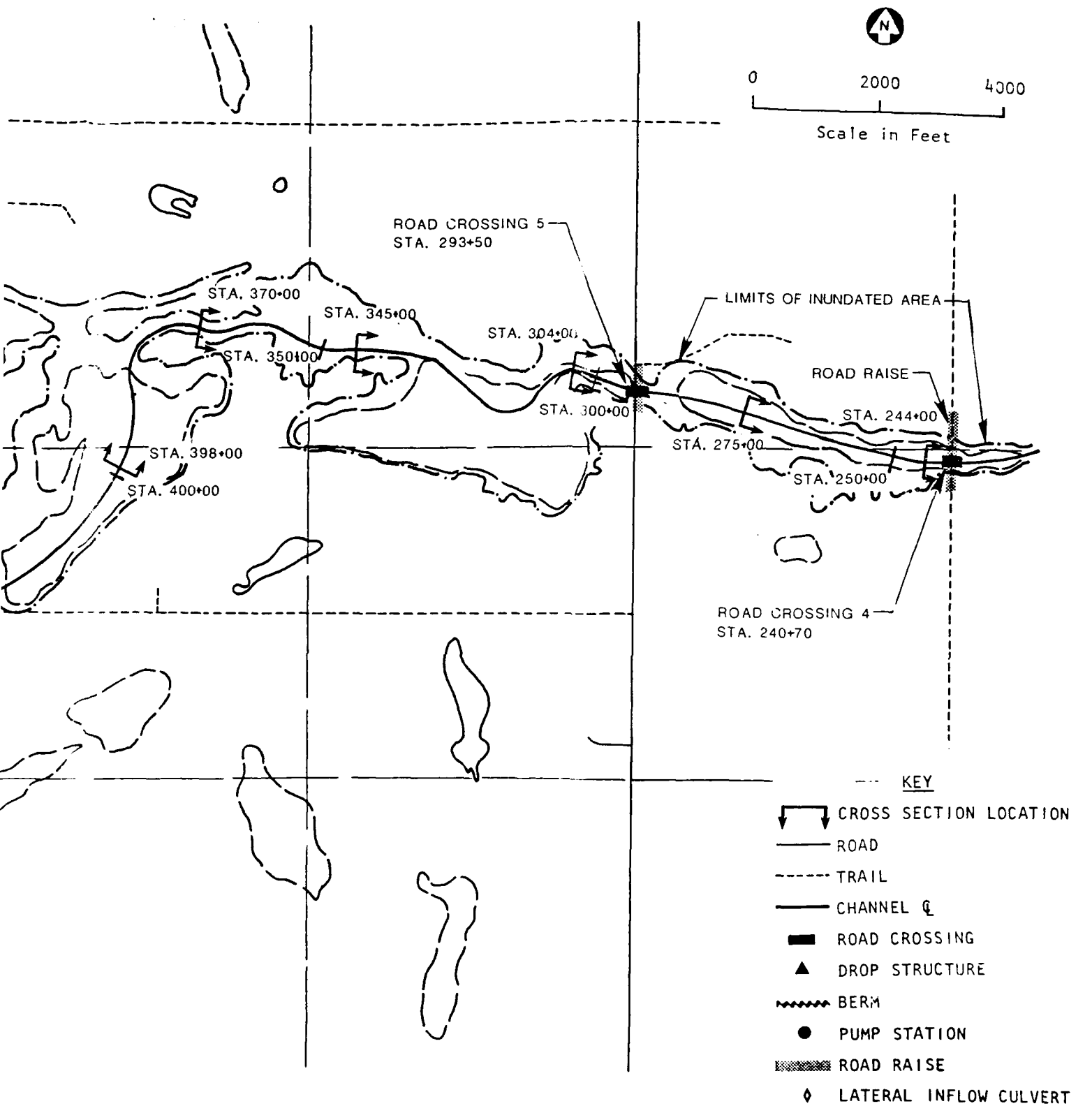
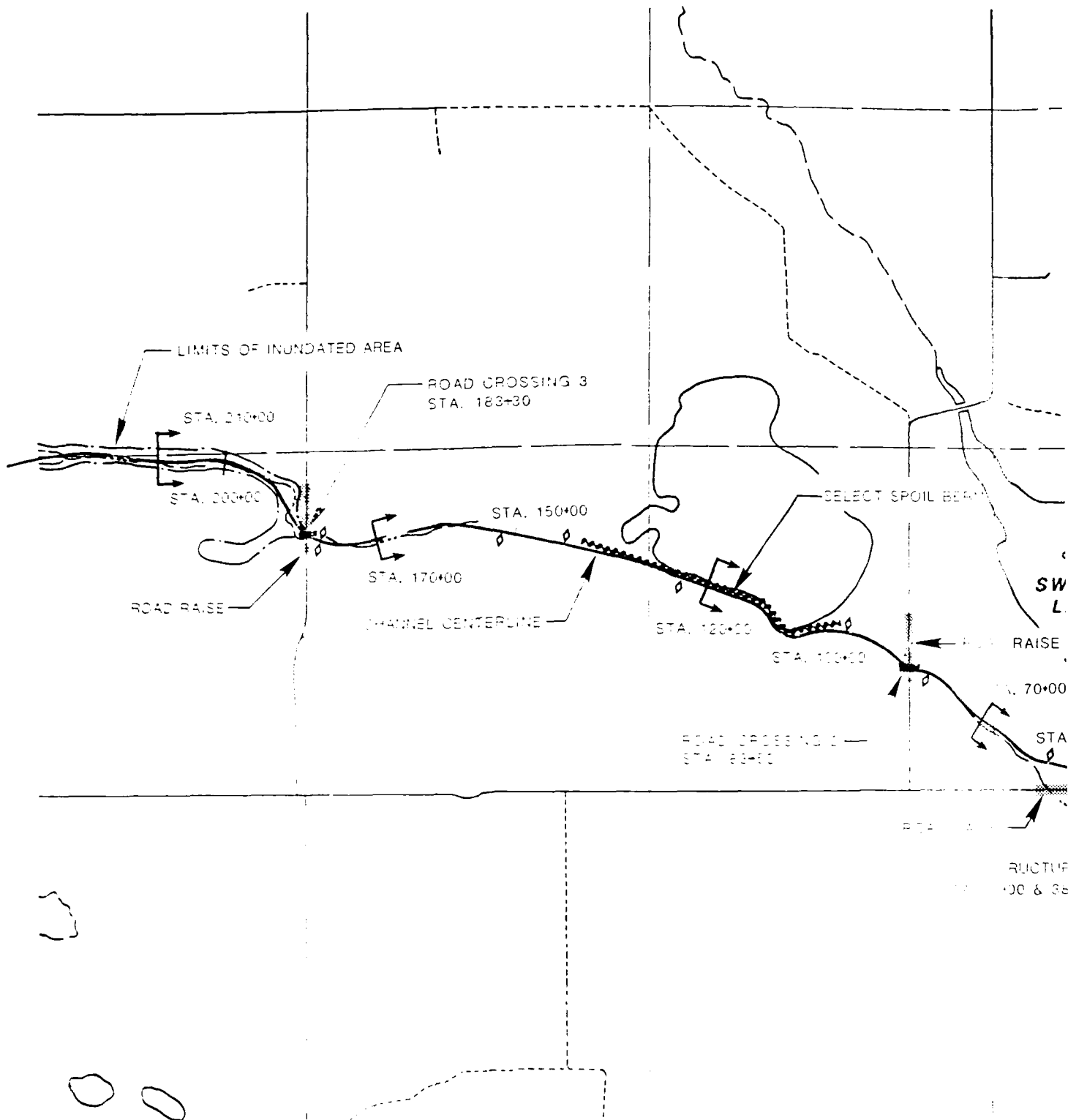


PLATE A-7  
LOCATION MAP  
CONNECTING CHANNEL  
EAST DEVILS LAKE TO WEST STUMP LAKE  
CASES 5A, 5B, & 5C

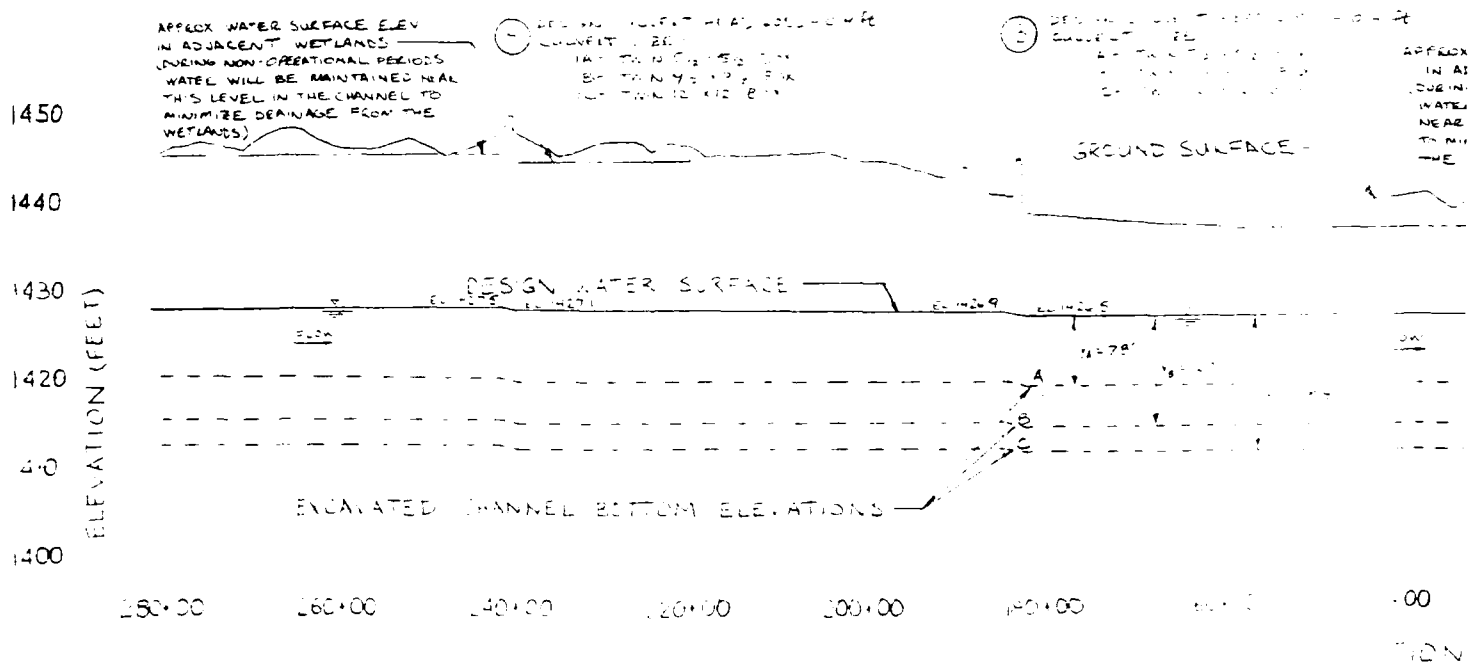
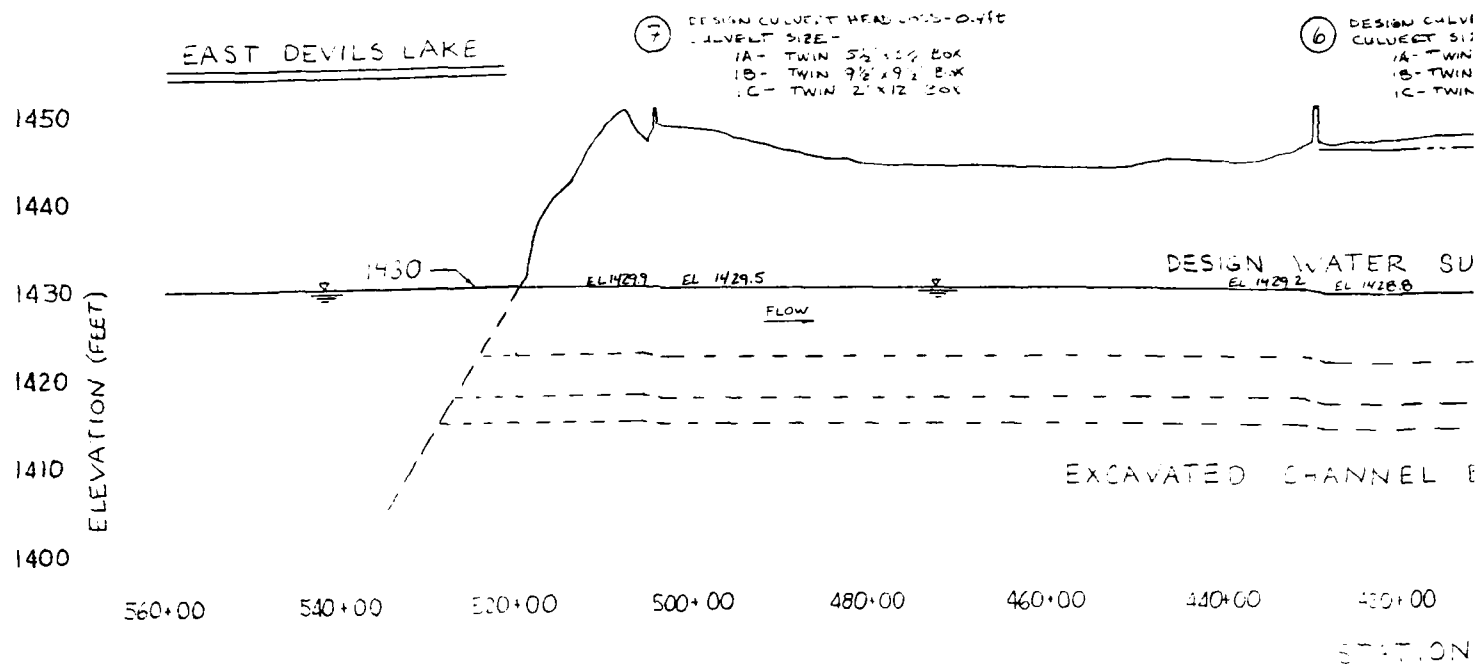






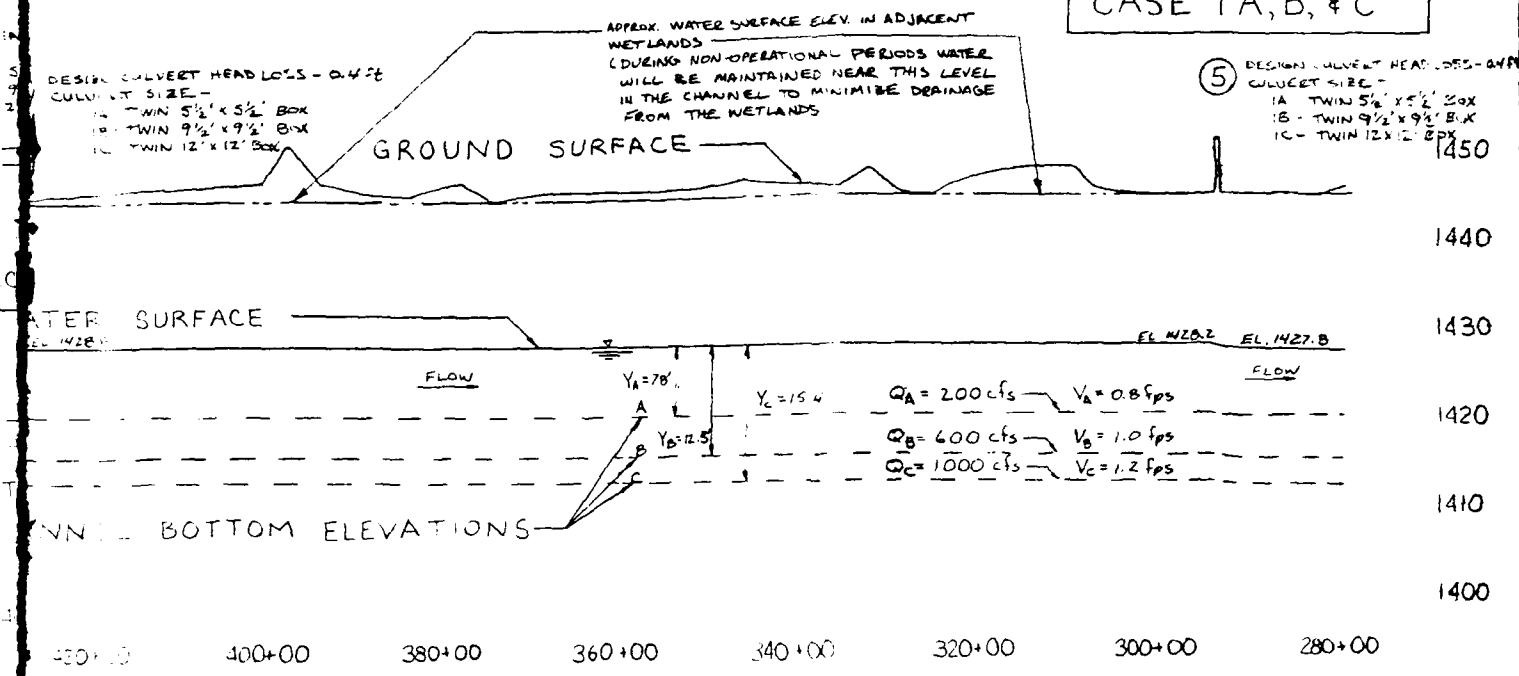
**APPENDIX B**  
CHANNEL PROFILES

DESIGN PROFILE FOR  
EAST DEVILS LAKE AND W



# PROFILE FOR CHANNEL CONNECTING AND WEST STUMP LAKE, NORTH DAKOTA

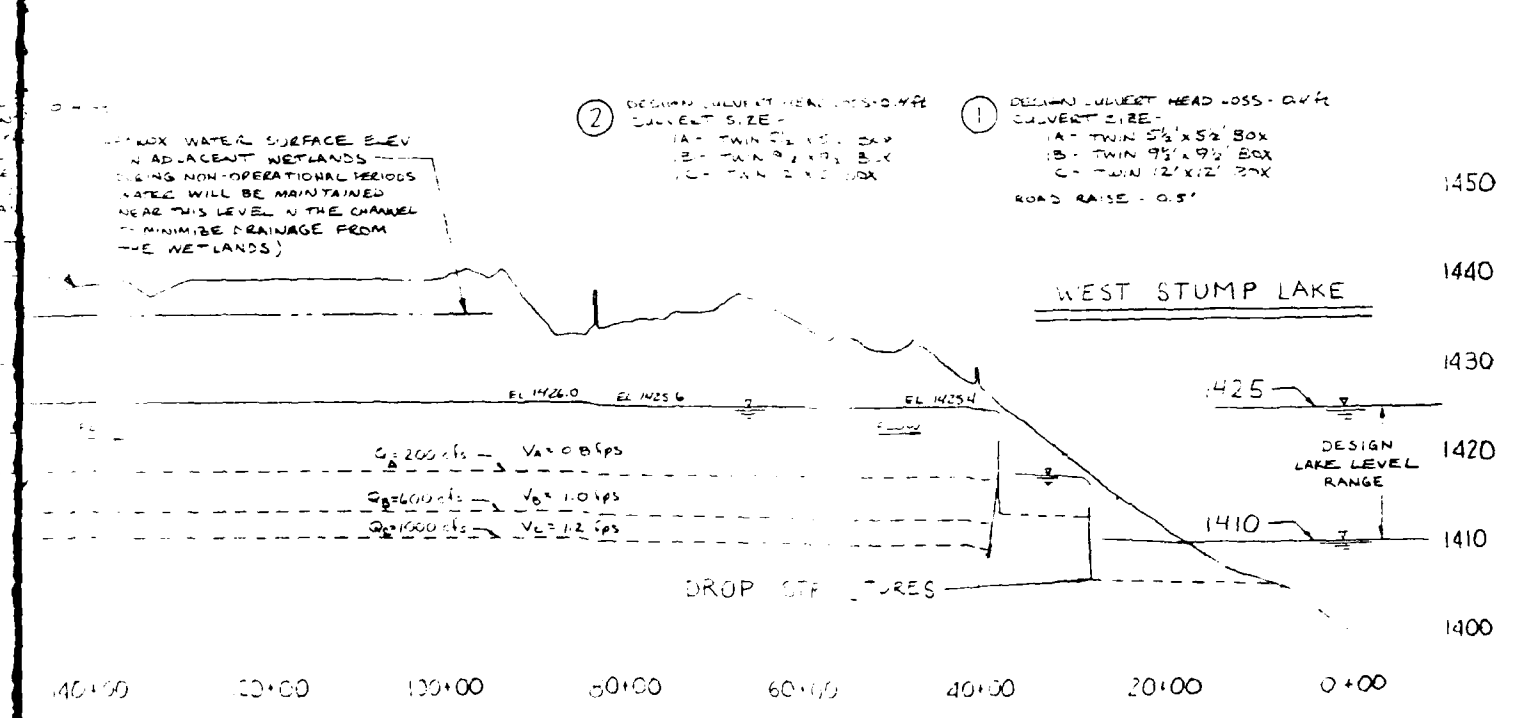
Fed. Proj. No. CASE 1A, B, & C



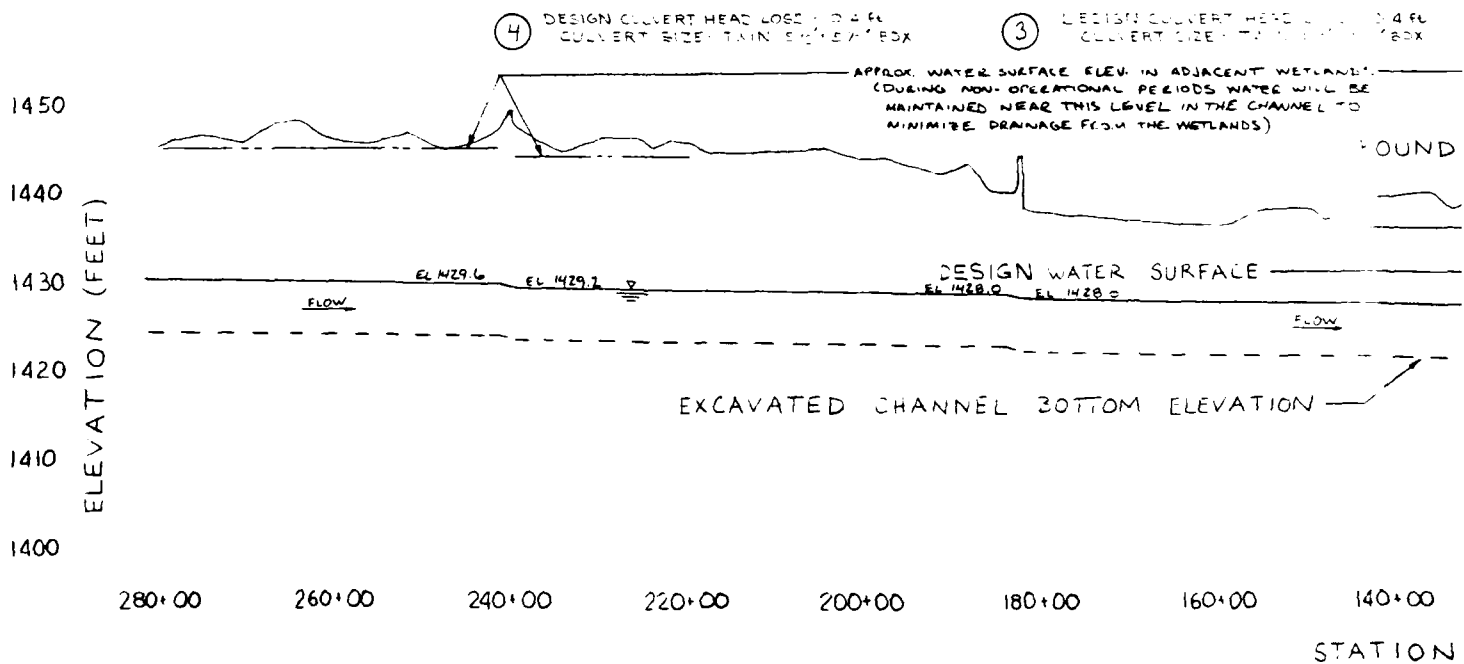
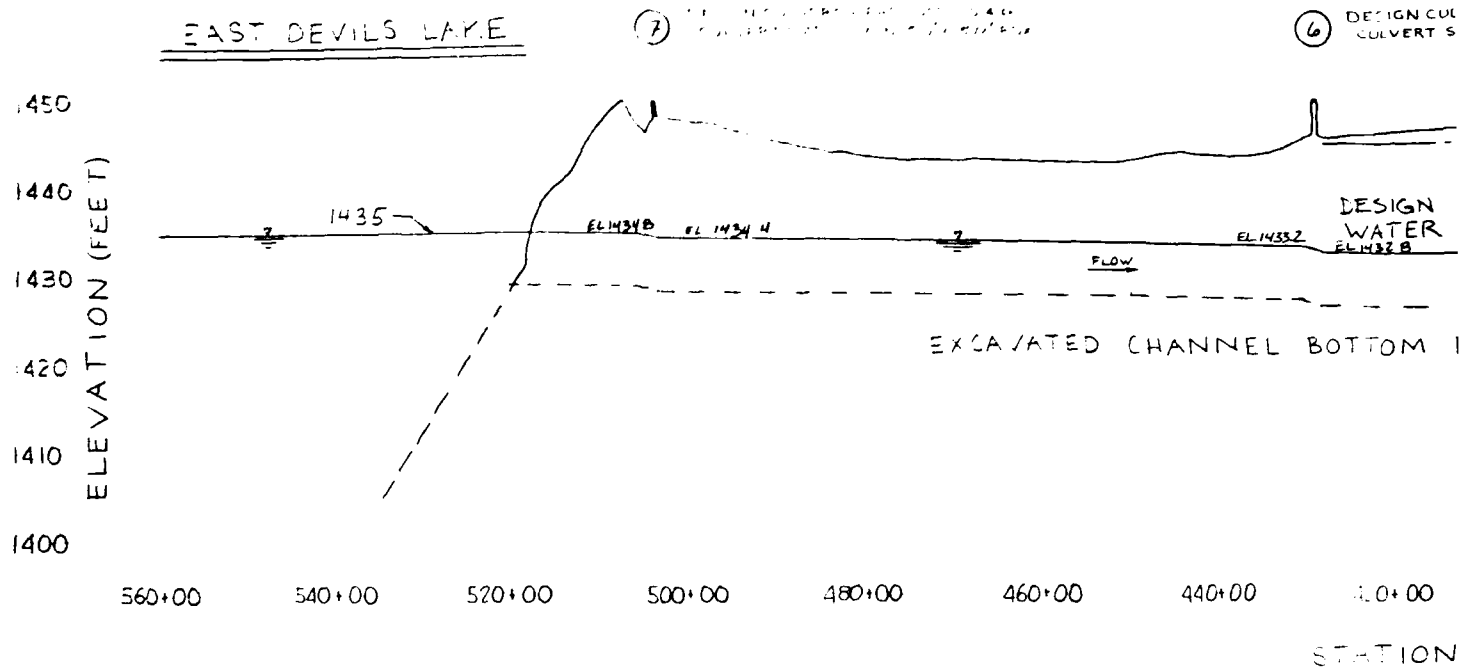
STATION

LONG. 100046.3, CENTAL LENGTH, ALL CASES

○ - ROAD CROSSINGS



# DESIGN PROFILE FOR (EAST DEVILS LAKE AND WEST DEVILS LAKE)



# PLAN FOR CHANNEL CONNECTING AND WEST STUMP LAKE, NORTH DAKOTA

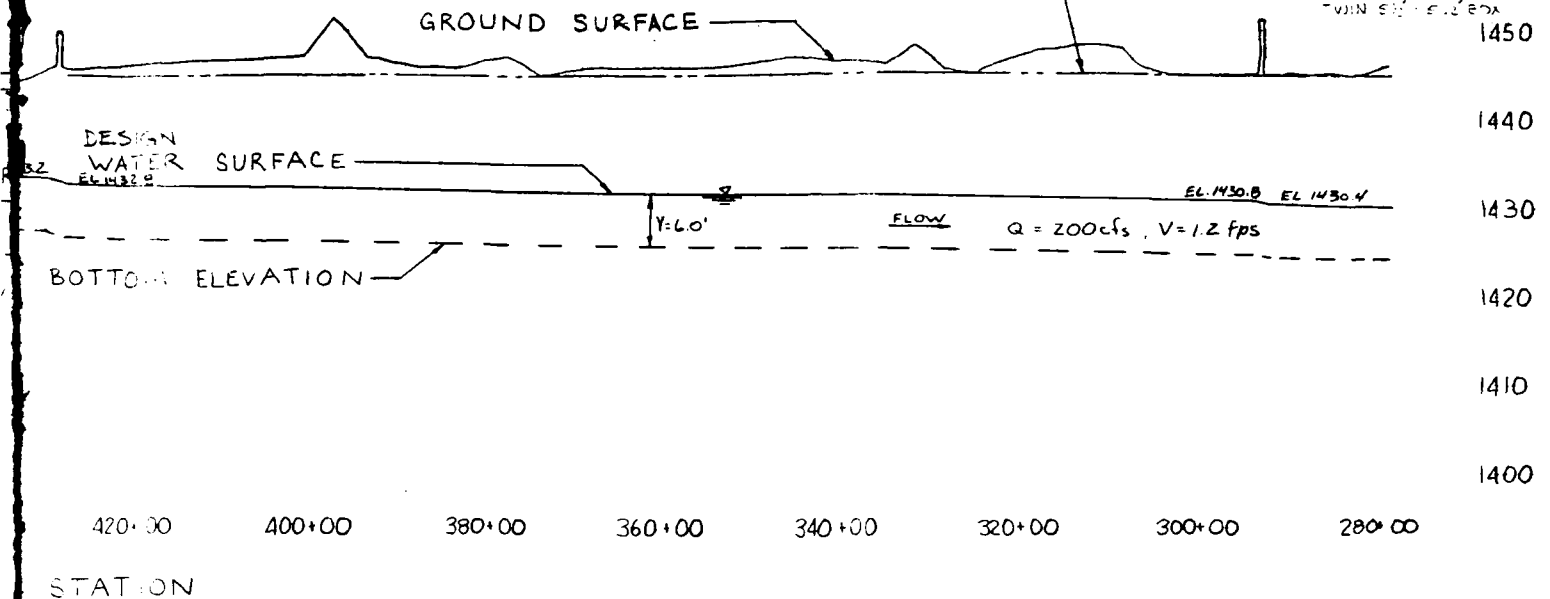
Fed. Proj. No.

CASE 2G

APPROX. WATER SURFACE ELEV. IN ADJACENT WETLANDS  
(DURING NON-OPERATIONAL PERIODS WATER WILL BE  
MAINTAINED NEAR THIS LEVEL TO MINIMIZE  
DRAINAGE FROM THE WETLANDS)

⑥ DESIGN CULVERT HEAD LOSS - 0.4 ft.  
CULVERT SIZE - TWIN 5 1/2' x 5 1/2' BOX

⑤ DESIGN CULVERT HEAD  
LOSS - 0.4 ft.  
CULVERT SIZE -  
TWIN 5 1/2' x 5 1/2' BOX



○ - ROAD CROSSINGS

THE ENTIRE LENGTH

② DESIGN CULVERT HEAD LOSS - 0.4 ft.  
CULVERT SIZE - TWIN 5' x 5' BOX

① DESIGN CULVERT HEAD LOSS - 0.4 ft.  
CULVERT SIZE - TWIN 5' x 5' BOX  
ROAD RAISE - 0.5'

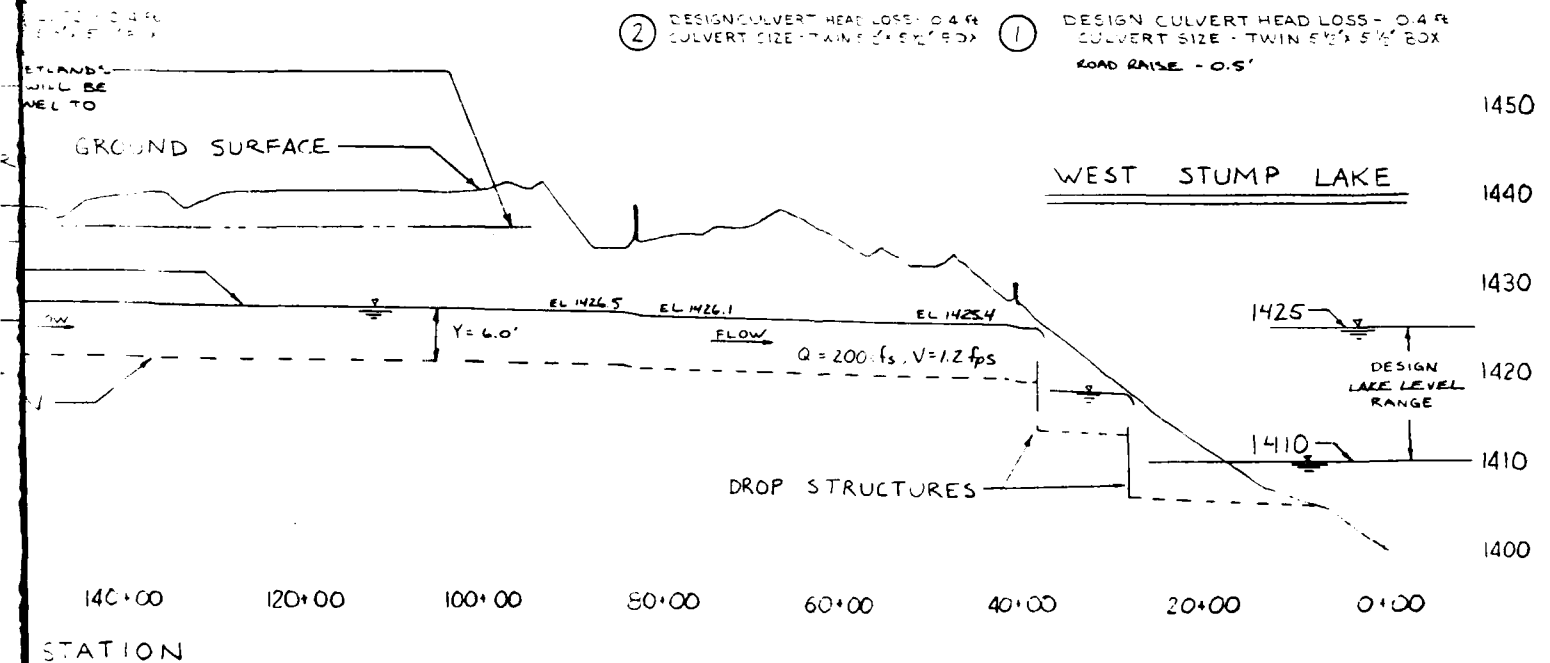
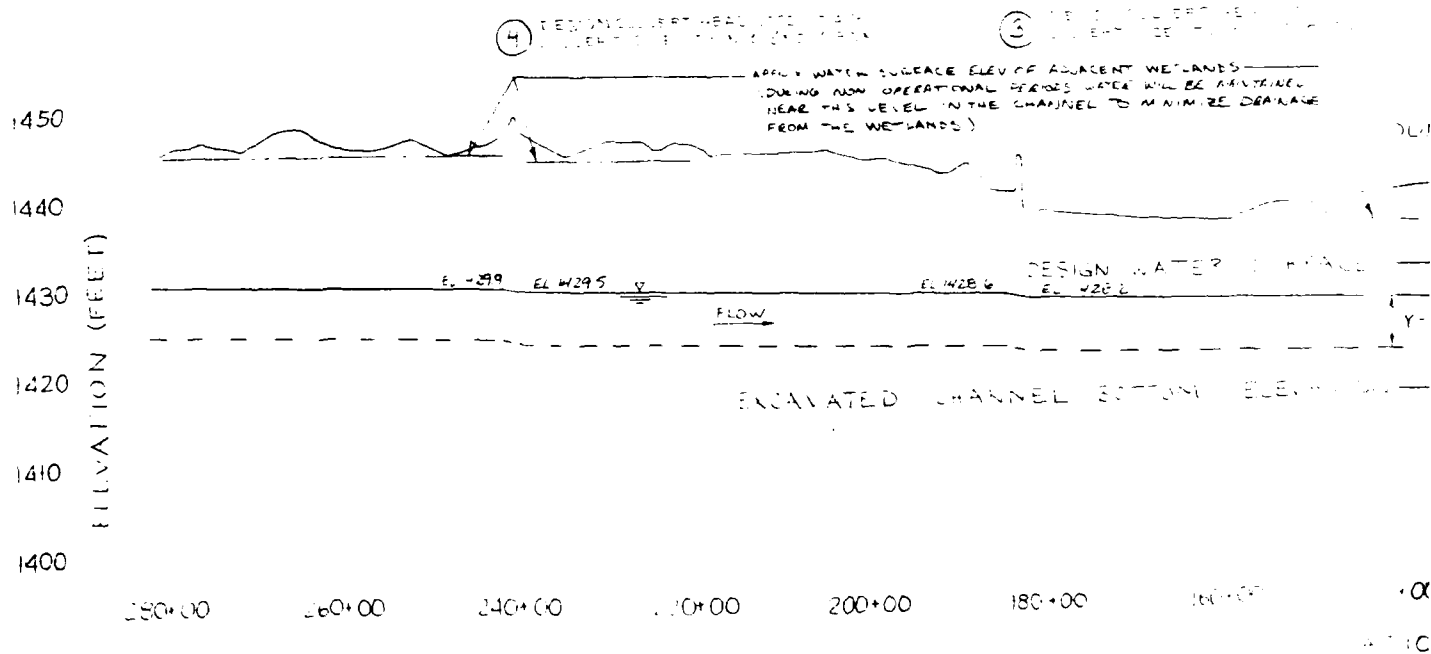
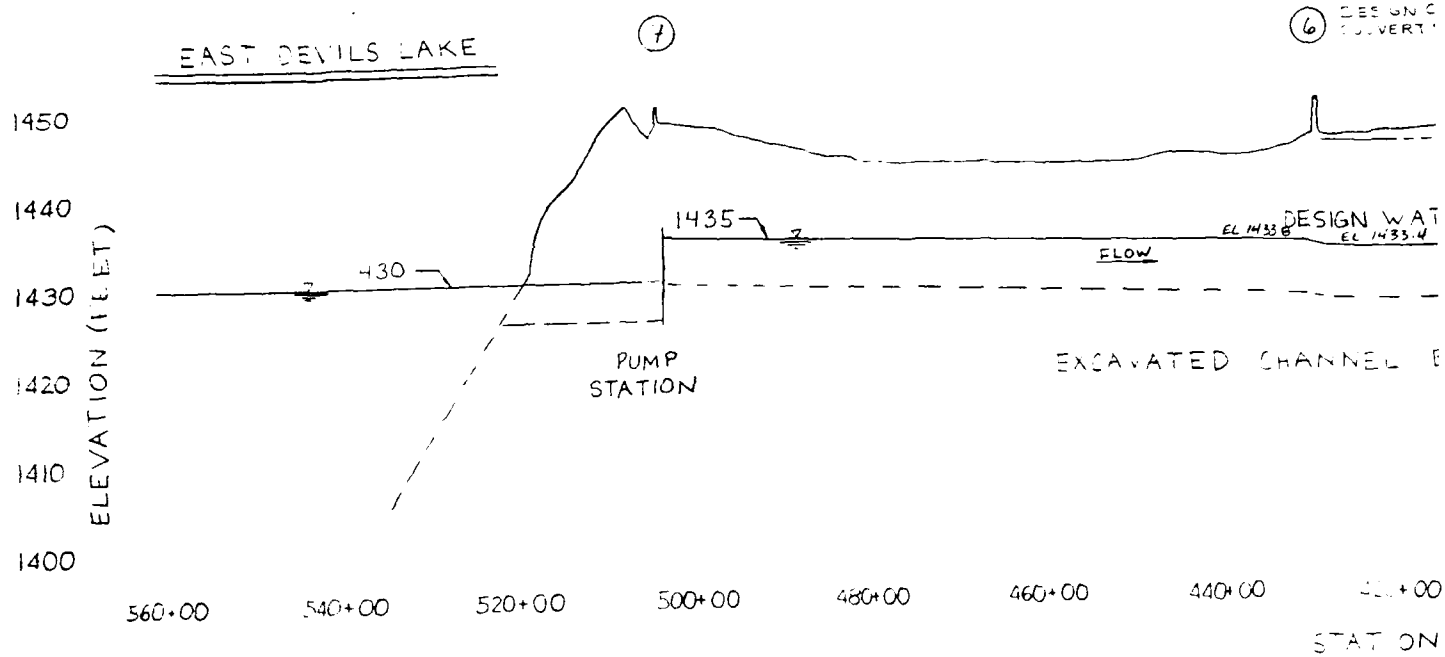


PLATE B-2

State Proj. No.

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# DESIGN PROFILE FOR CHA EAST DEVILS LAKE AND WEST S



# OR CHANNEL CONNECTING WEST STUMP LAKE, NORTH DAKOTA

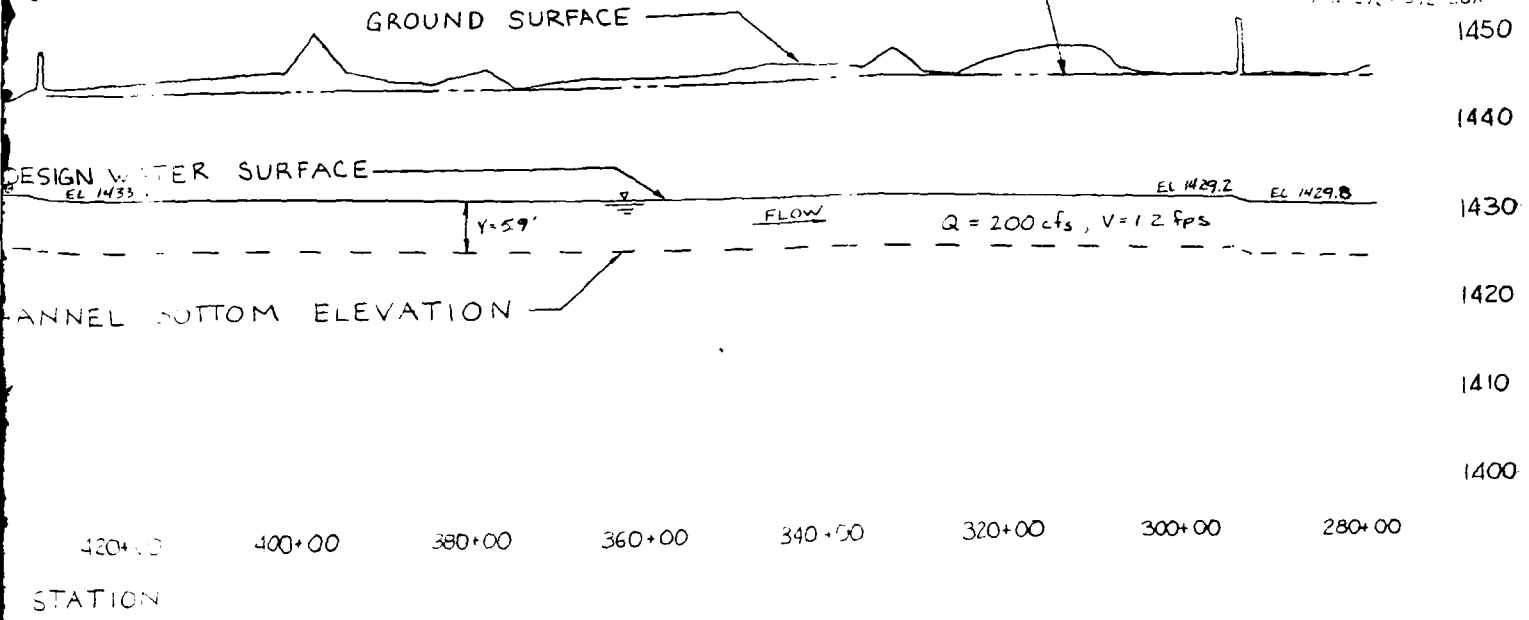
Fed. Proj. No.

CASE 2 P

⑥ DESIGN CULVERT HEAD LOSS - 0.4 ft  
CULVERT SIZE - TWIN 5' x 5' BOX

APPROX WATER SURFACE ELEV IN ADJACENT WETLANDS  
(DURING NON-OPERATIONAL PERIODS WATER WILL BE  
MAINTAINED NEAR THIS LEVEL TO MINIMIZE  
DRAINAGE FROM THE WETLANDS)

⑤ DESIGN CULVERT HEAD LOSS - 0.5 ft  
CULVERT SIZE - TWIN 5' x 5' BOX



○ - ROAD CROSSINGS

ENTIRE LENGTH

② DESIGN CULVERT HEAD LOSS - 0.5 ft  
CULVERT SIZE - TWIN 5' x 5' BOX

① DESIGN CULVERT HEAD LOSS - 0.5 ft  
CULVERT SIZE - TWIN 5' x 5' BOX  
ROAD RAISE - 0.5'

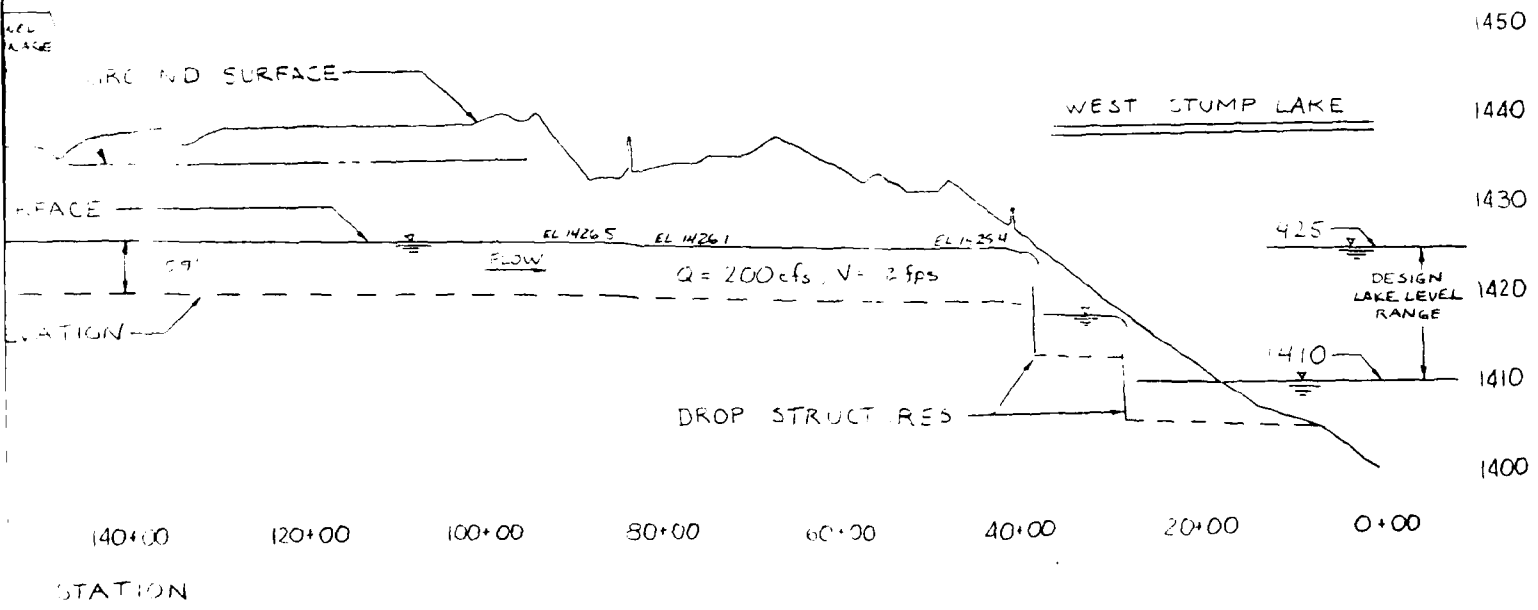
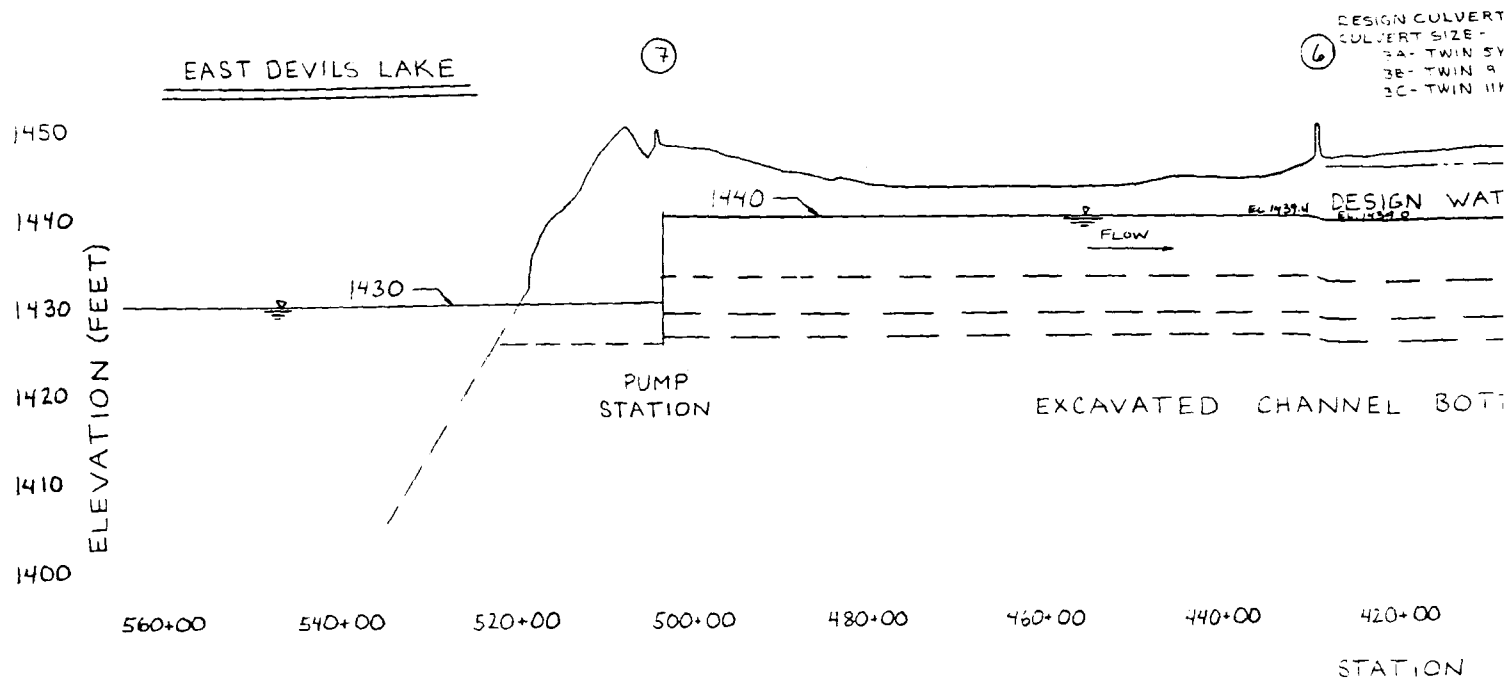


PLATE B-3

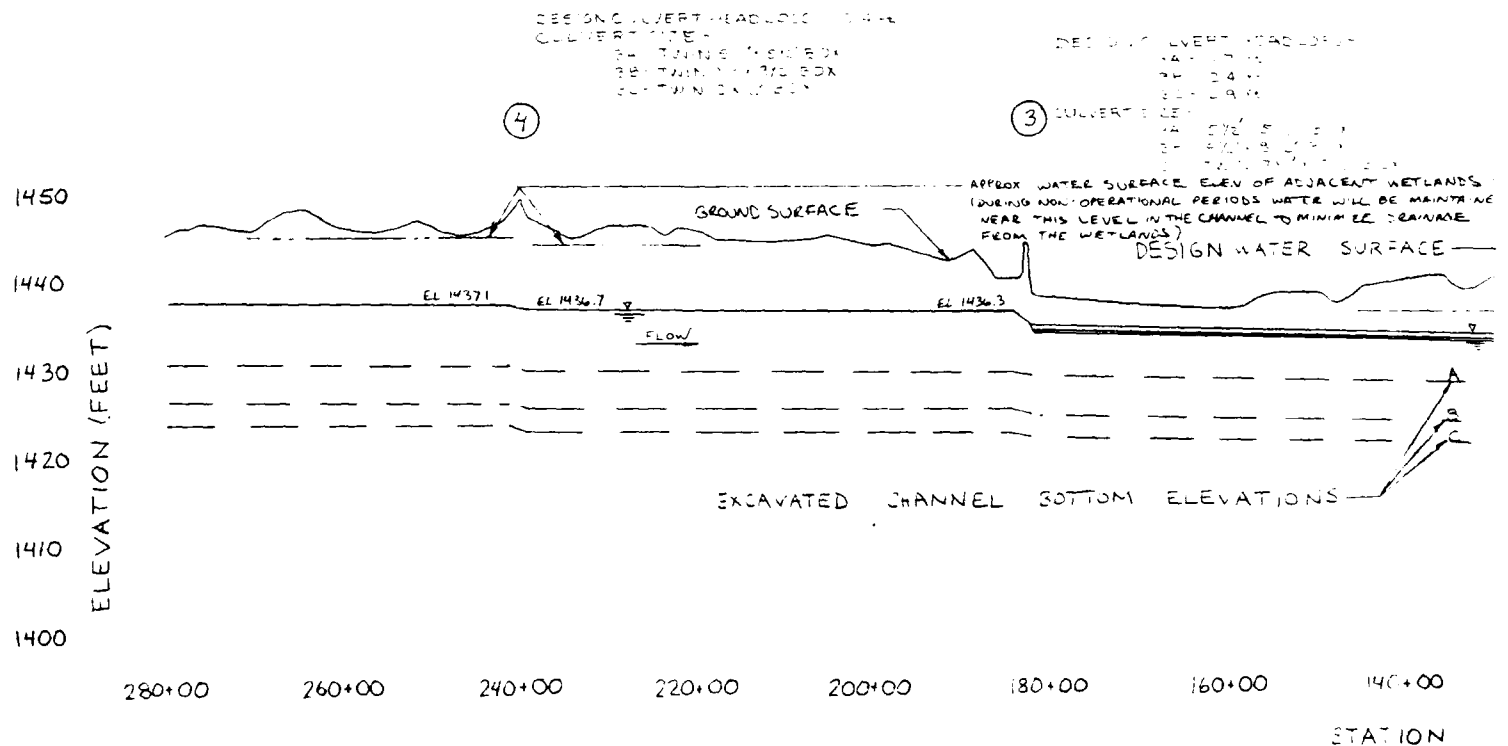
State Proj. No.

of Sheets

# DESIGN PROFILE FOR CHANNEL EAST DEVILS LAKE AND WEST ST



CHANNEL SLOPE - 0.02% SUMP LAKE  
0.0075% ROAD C  
0.3% ROAD CENTERLINE



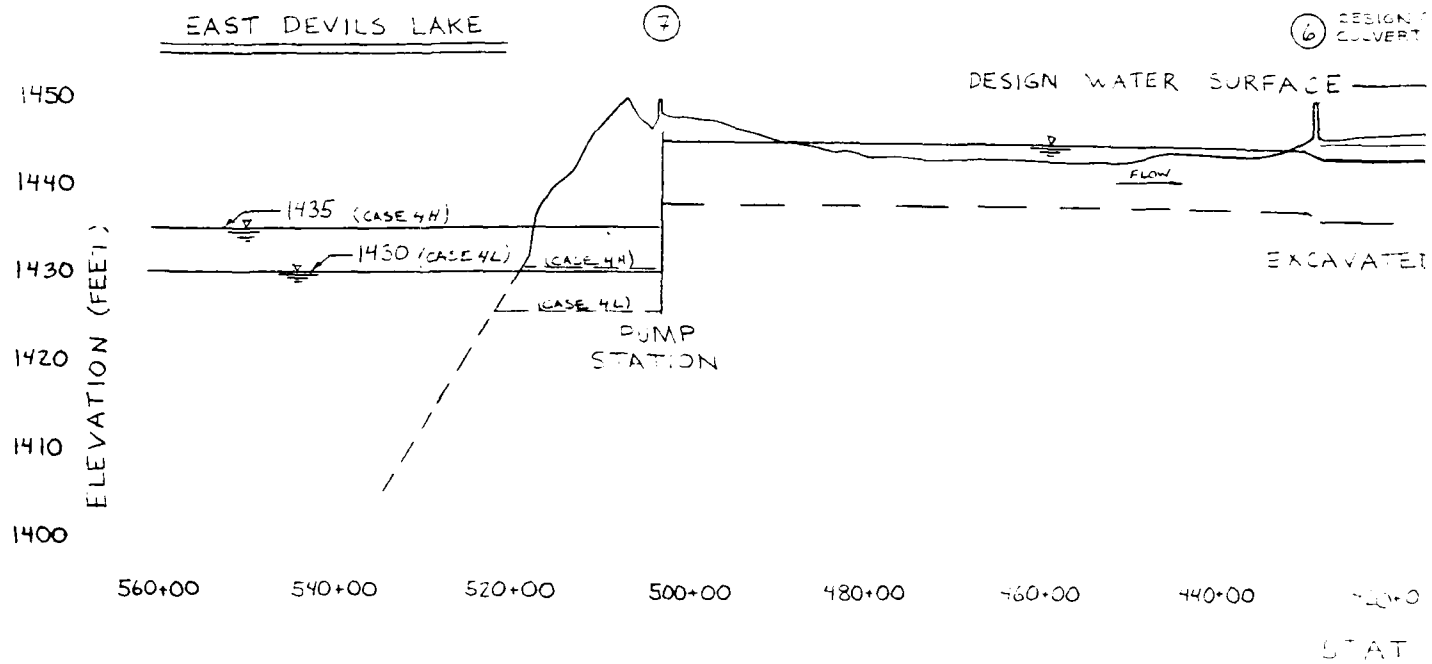


CASE 3 A, B, & C

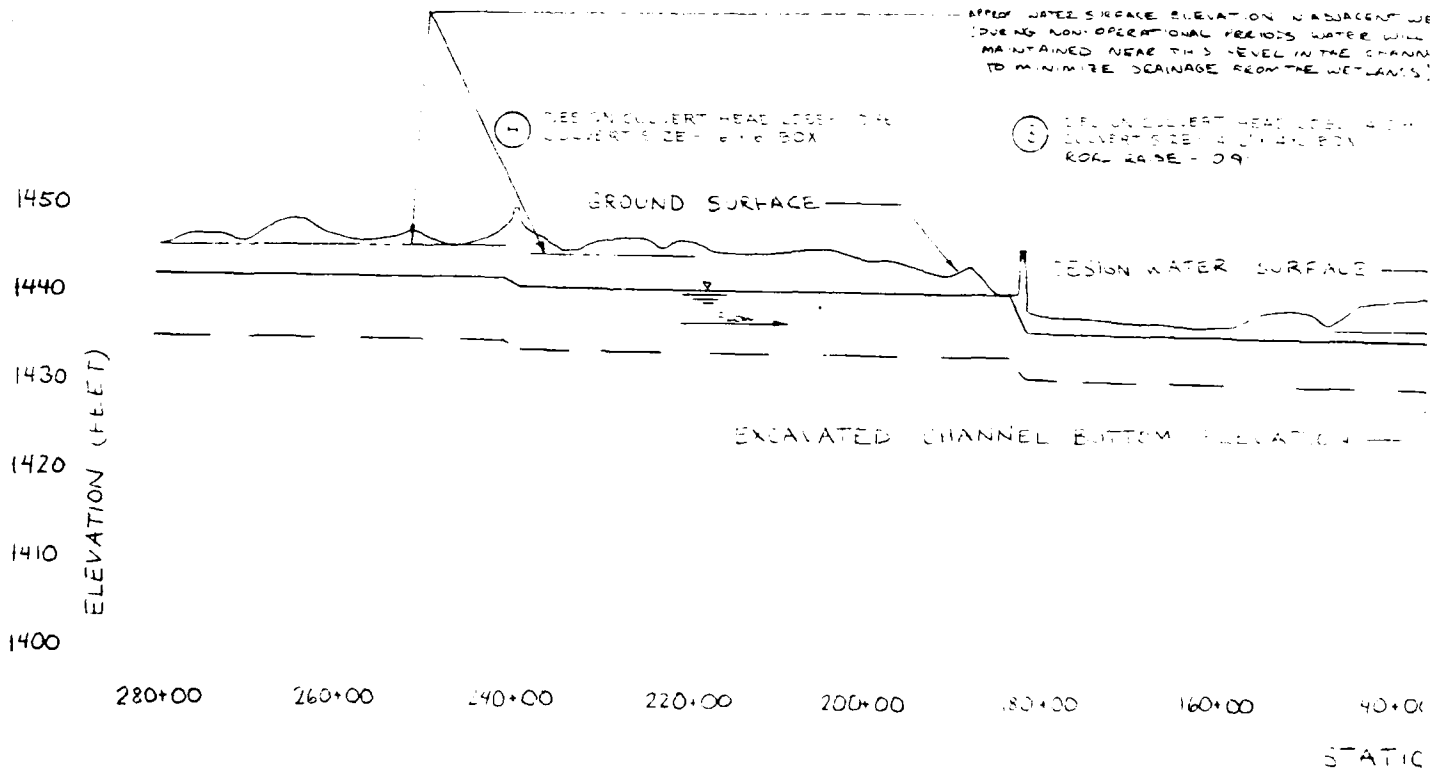
5



# DESIGN PROFILE FOR C EAST DEVILS LAKE AND WEST



CHANNEL SLOPE - 0.02% (ST  
0.0066% (H  
0% ROAD CE



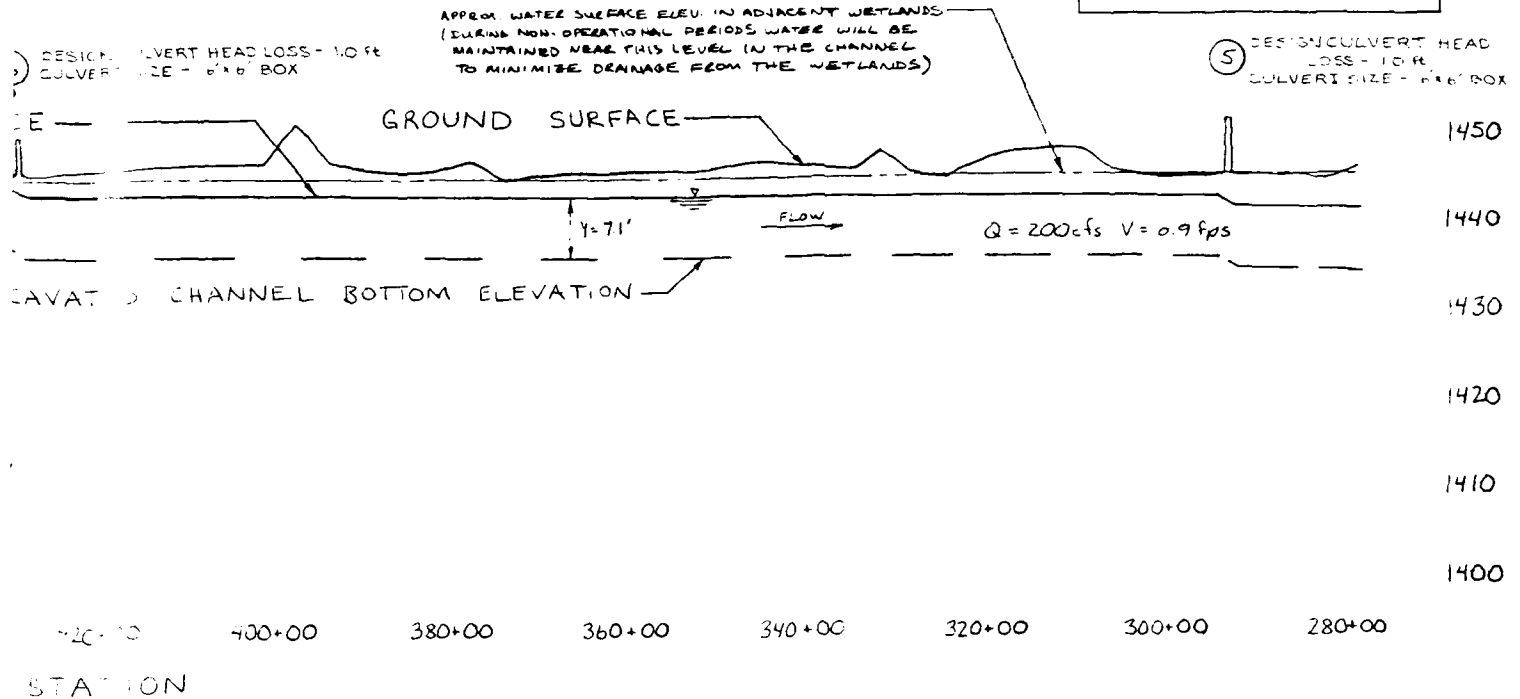
DESIGN COVERT HEAD LOSS - 0.4  
COVERTS 24" x 48" BOX

DESIGN COVERT HEAD LOSS - 0.4  
COVERTS 24" x 48" BOX  
ROAD CASE - 0.9

APPLY WATER SURFACE ELEVATION IN ADJACENT WETLANDS  
(DURING NON-OPERATIONAL PERIODS WATER WILL  
MAINTAINED NEAR THIS LEVEL IN THE CHANNEL  
TO MINIMIZE DRAINAGE FROM THE WETLANDS)

CASE 4 L & H

# FOR CHANNEL CONNECTING WEST STUMP LAKE, NORTH DAKOTA



2.2% STUMP LAKE TO ROAD CROSSING 3  
DOGGY ROAD CROSSING 3 TO ROAD CROSSING 7  
ROAD CROSSING 7 TO DEVILS LAKE

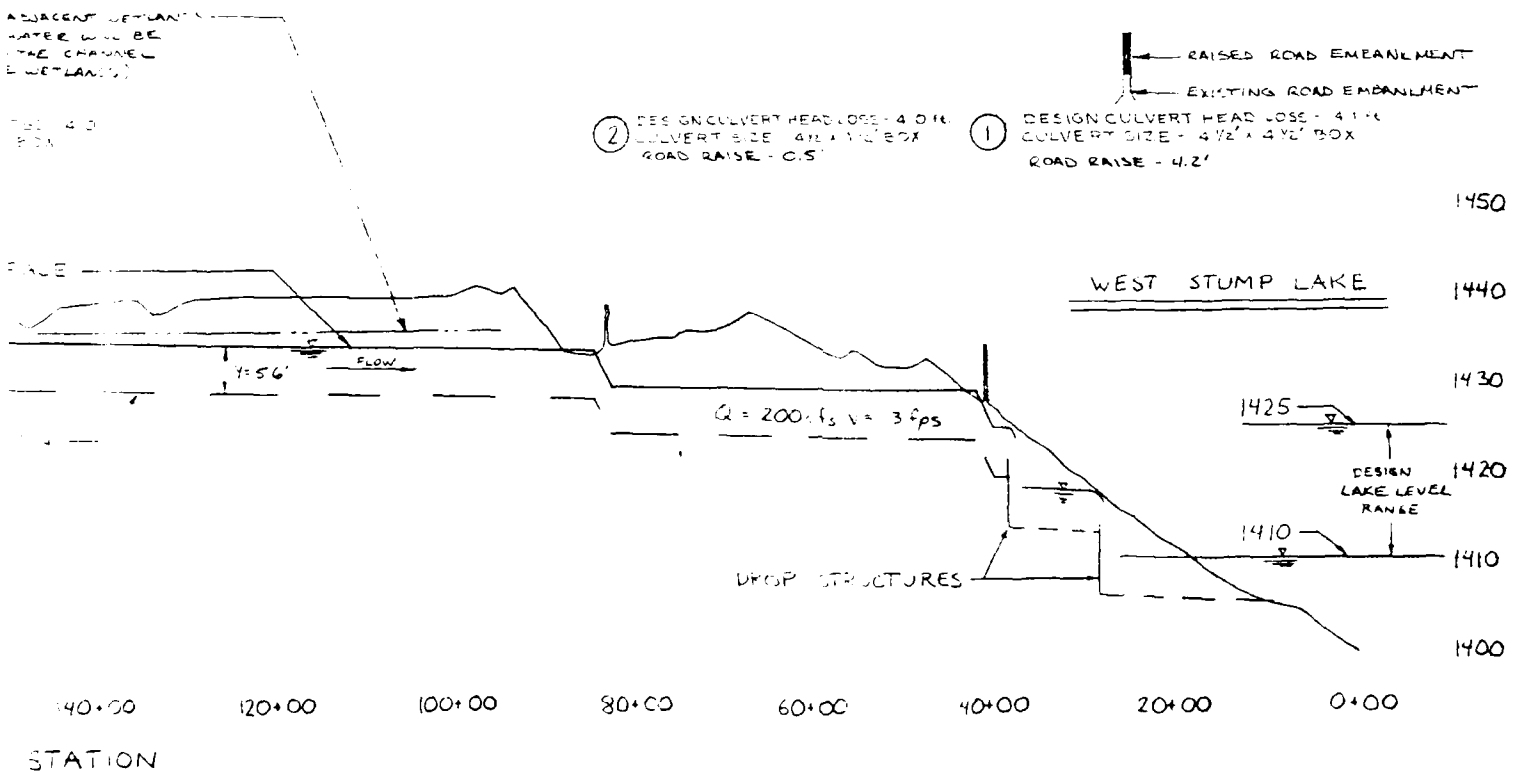
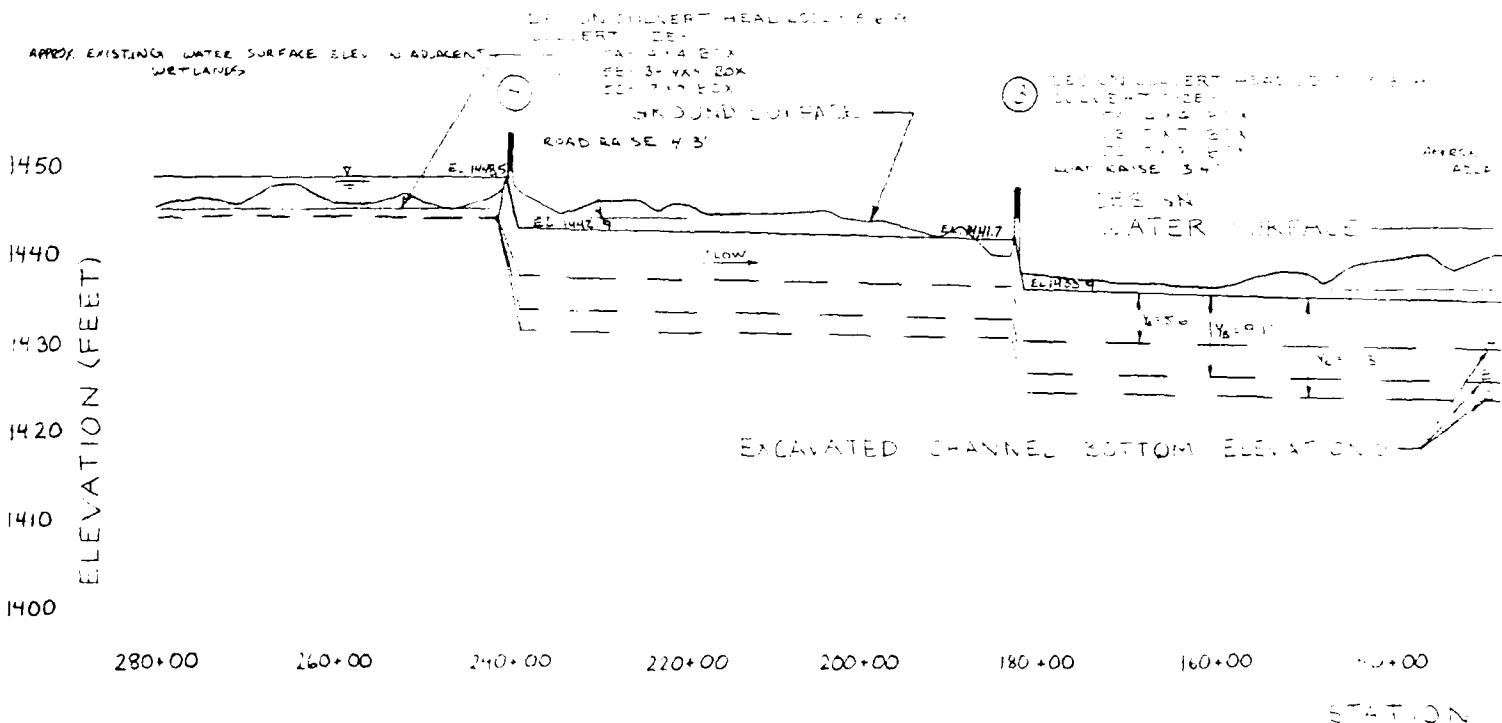
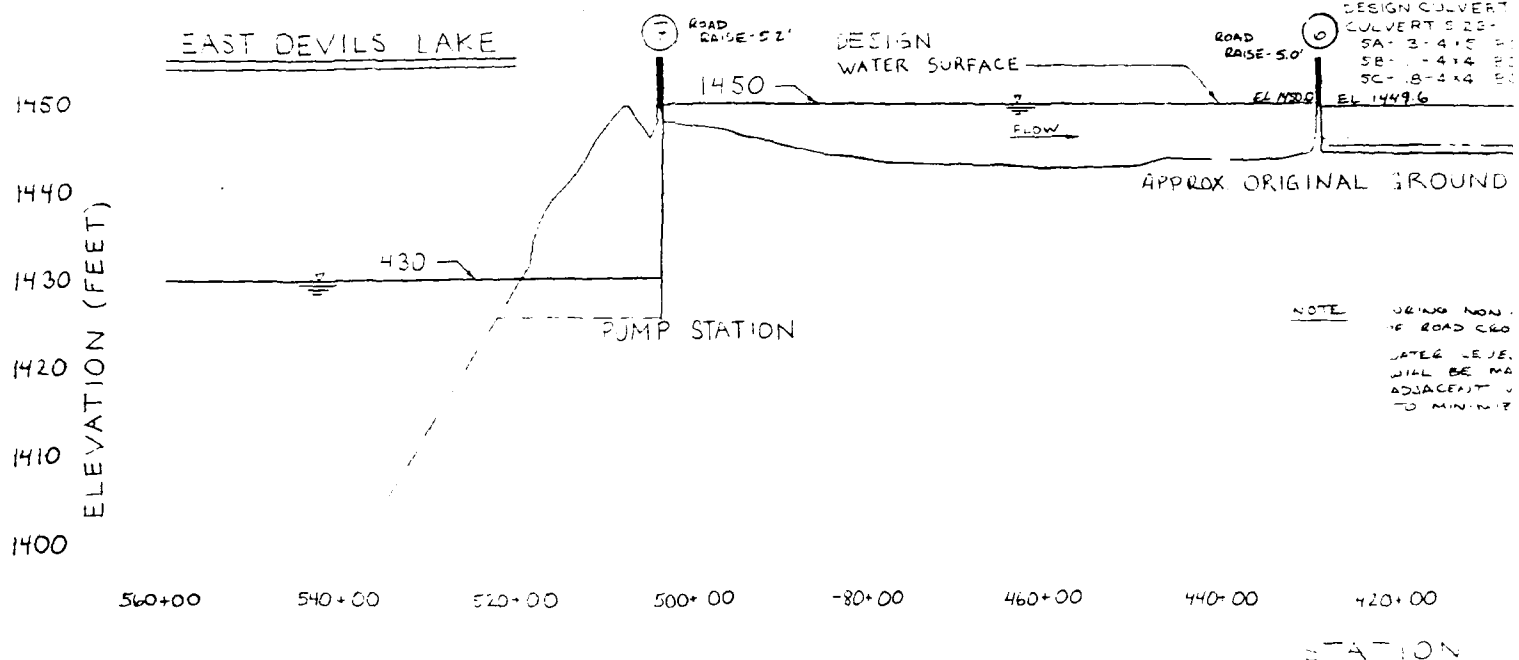


PLATE B-5

# DESIGN PROFILE FOR CHANNEL EAST DEVILS LAKE AND WEST



# CHANNEL CONNECTING WEST STUMP LAKE, NORTH DAKOTA

Fed. Proj. No.

CASE 5 A, B, & C

DESIGN CULVERT HEAD LOSS - 0.4 FT

CULVERT SIZE -

SA - 3' x 4' x 5' BOX

SB - 4' x 4' x 4' BOX

SC - 8' x 4' x 4' BOX

EL 1449.6

APPROX. EXISTING WATER SURFACE ELEV.  
IN ADJACENT WETLANDS

DESIGN CULVERT HEAD

LOSS - 0.4 FT

CULVERT SIZE -

SA - 3' x 4' x 5' BOX

SB - 4' x 4' x 4' BOX

SC - 8' x 4' x 4' BOX

EL 1449.9

ROAD RAISE - 2.9'

EL 1449.3

1450

GROUND SURFACE USED FOR CHANNEL BOTTOM

1440

1430

1420

1410

1400

DURING NON-OPERATIONAL PERIODS INUNDATED AREAS UPSTREAM  
OF ROAD CROSSING 4 WILL BE MAINTAINED

WATER LEVELS IN THE CHANNEL DOWNSTREAM OF ROAD CROSSING 4  
WILL BE MAINTAINED NEAR WATER SURFACE ELEV IN THE  
ADJACENT WETLANDS DURING NON-OPERATIONAL PERIODS  
TO MINIMIZE DRAINAGE FROM THE ADJACENT WETLANDS.

420+00 400+00 380+00 360+00 340+00 320+00 300+00 280+00

STATION

WEST STUMP LAKE IS ROAD CROSSING 4, ALL CASES  
AND SLOPE ROAD CROSSING 4 TO ROAD CROSSING 7, ALL CASES  
CROSSING 7 TO DEVILS LAKE, ALL CASES

○ - ROAD CROSSINGS

RAISED ROAD EMBANKMENT  
EXISTING ROAD EMBANKMENT

② DESIGN CULVERT HEAD LOSS - 4.0 FT  
CULVERT SIZE -

SA - 4' x 4' x 4' BOX

SB - 7' x 7' x 7' BOX

SC - 9' x 7' x 7' BOX

ROAD RAISE - 0.5'

① DESIGN CULVERT HEAD LOSS - 4.0 FT  
CULVERT SIZE -

SA - 4' x 4' x 4' BOX

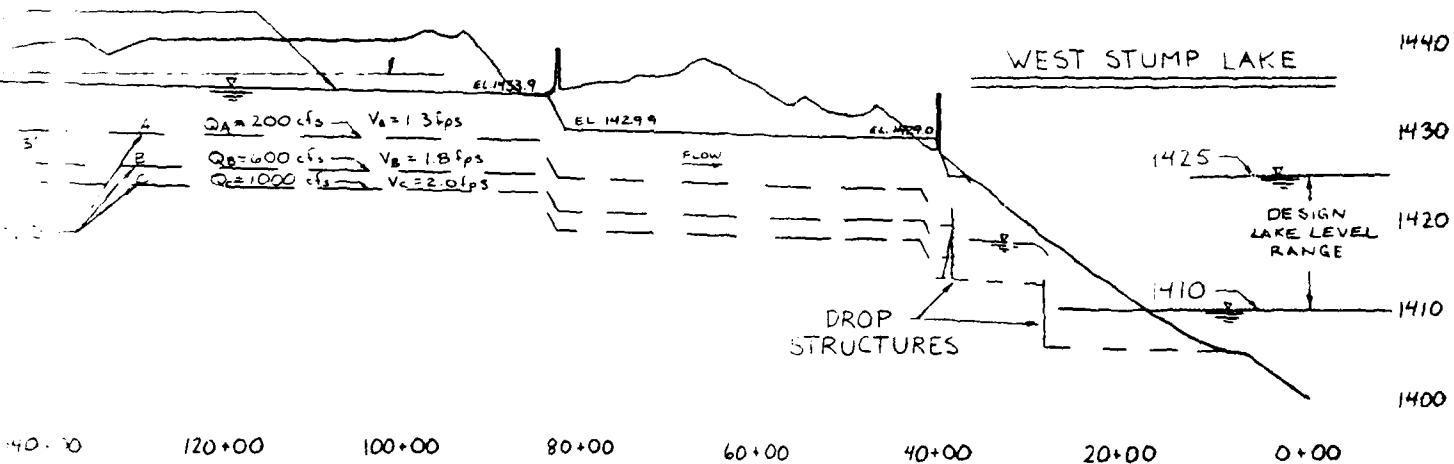
SB - 7' x 7' x 7' BOX

SC - 9' x 7' x 7' BOX

ROAD RAISE - 4.2'

1450

APPROX. WATER SURFACE ELEV IN  
ADJACENT WETLANDS



STATION

PLATE B-6

State Proj. No.

Sheet No. of Sheets

**APPENDIX C**  
CHANNEL CROSS SECTIONS

1450

1440

1430

1420

1410

1400

(Same as RT side)

EXISTING GROUND

W.S. ELEV 1410.2

1405.8

120<sub>LT</sub>

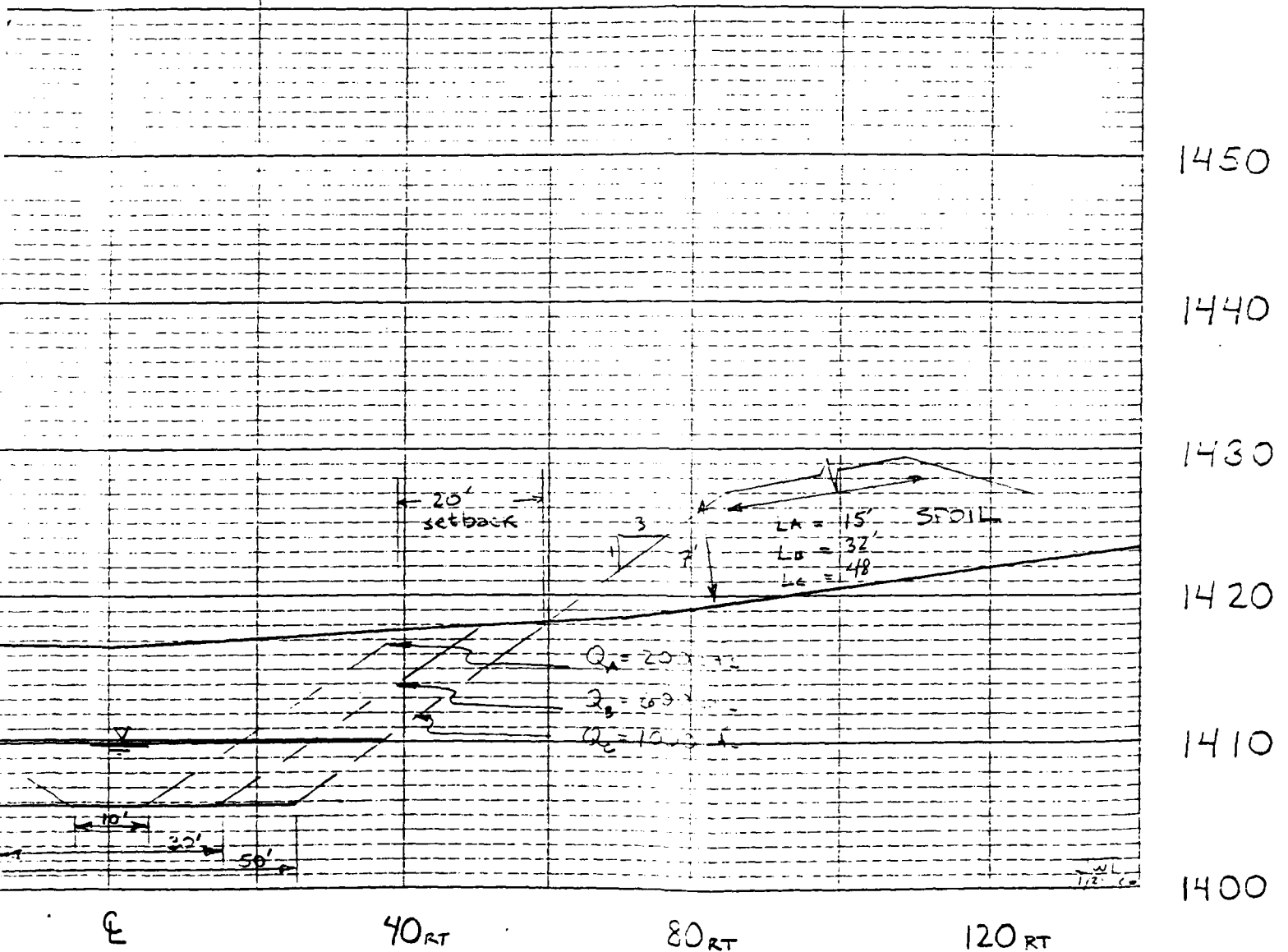
80<sub>LT</sub>

40<sub>LT</sub>

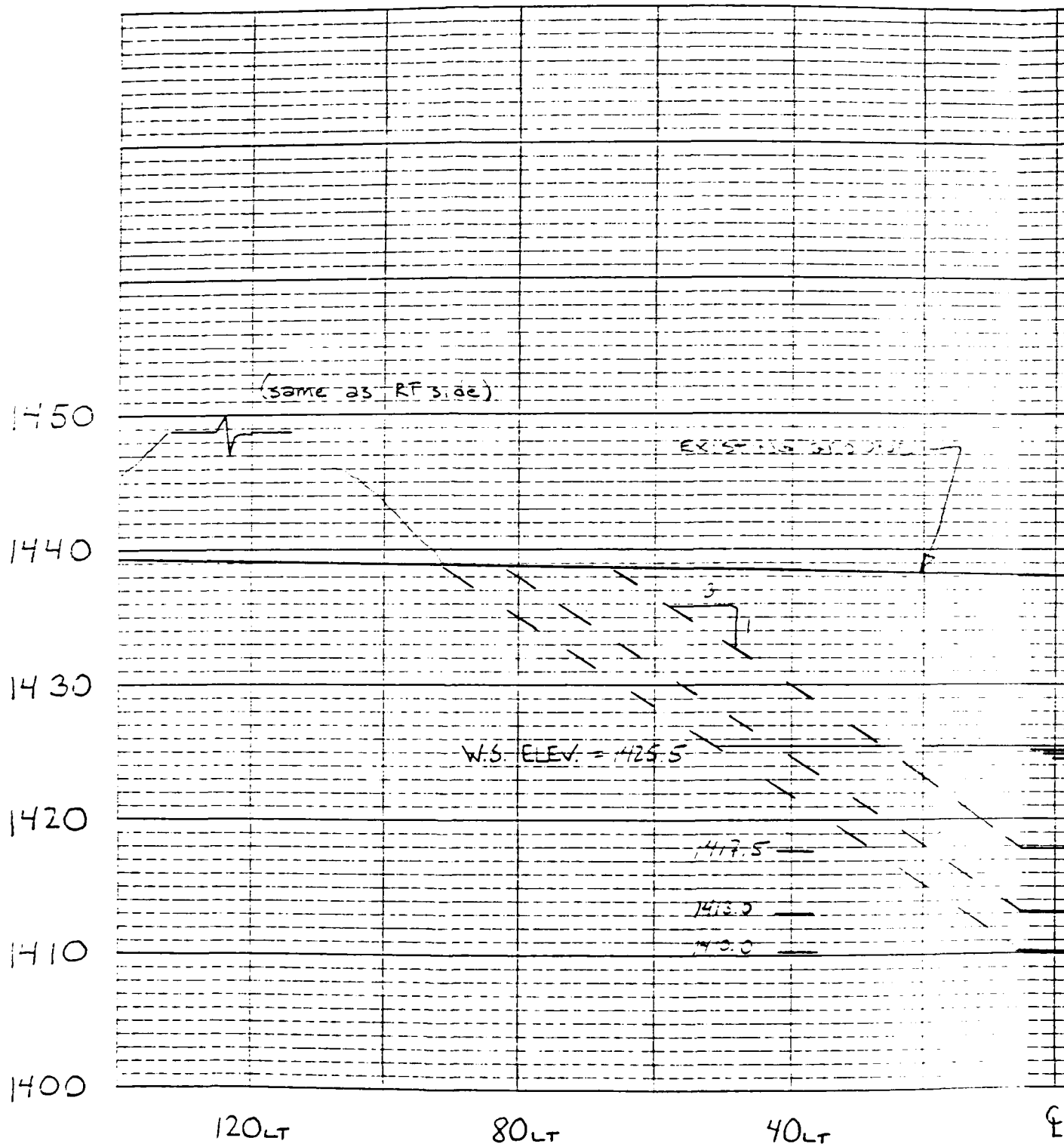
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 1A, B & C

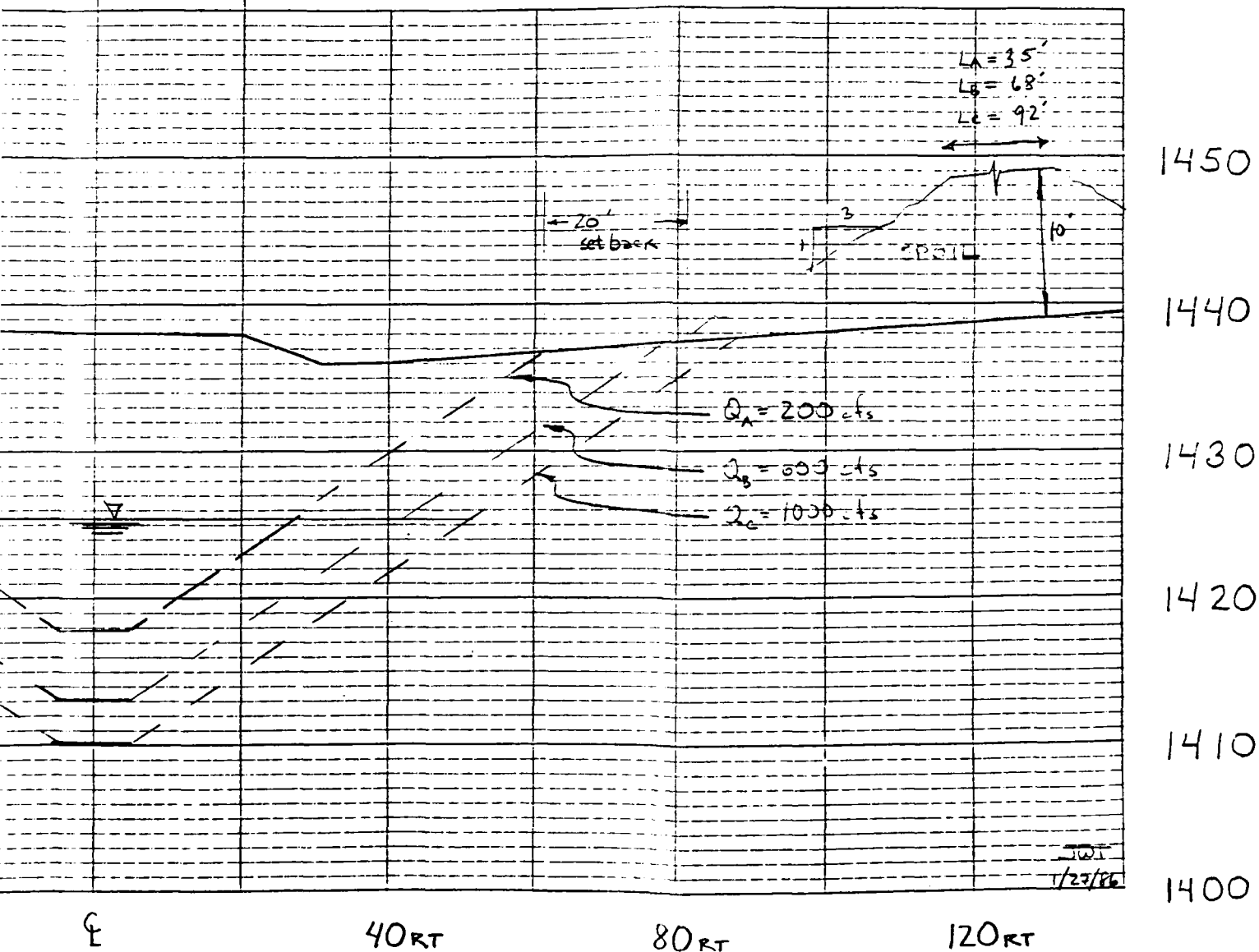
CROSS SECTION STA 25+00

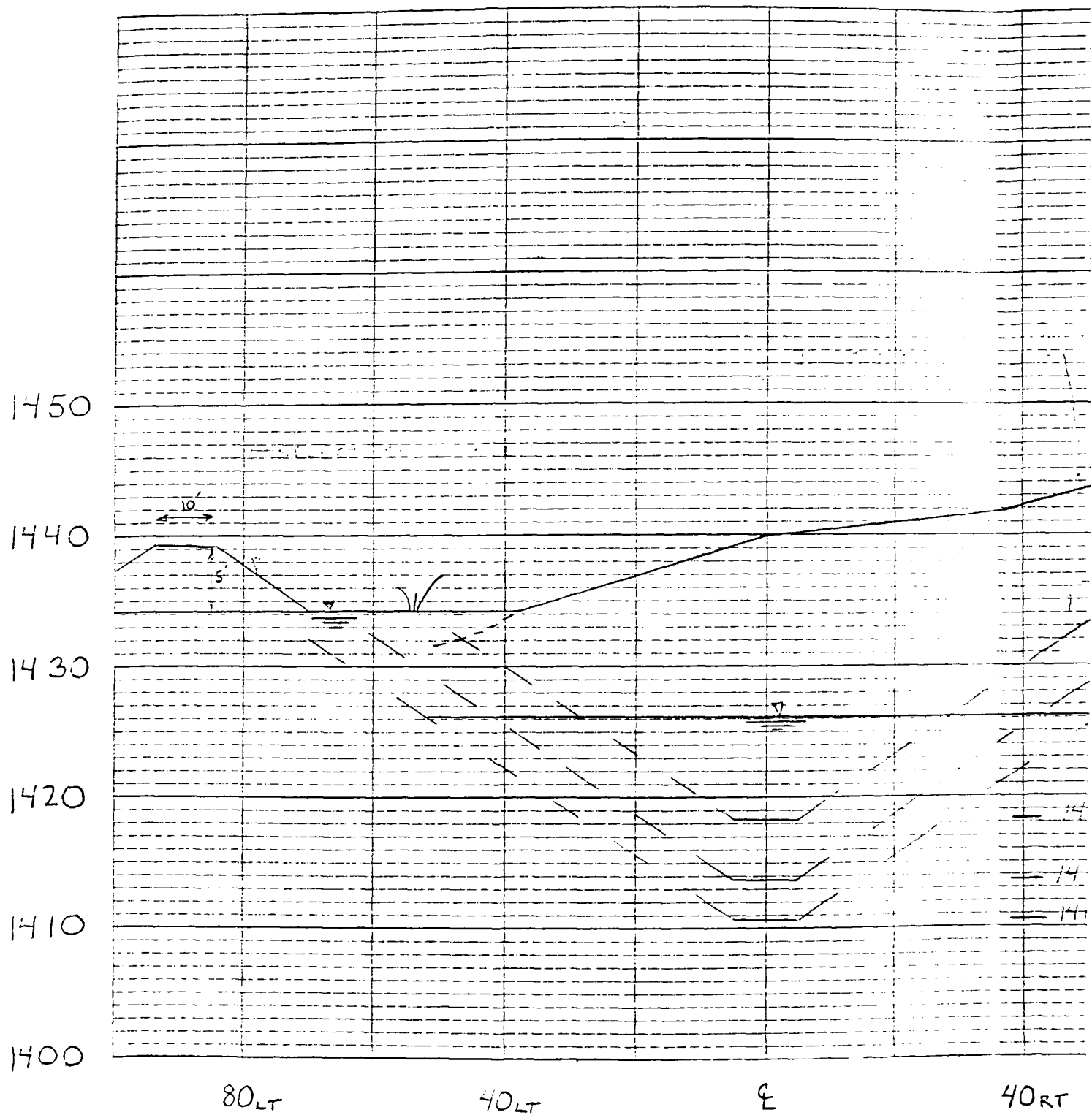






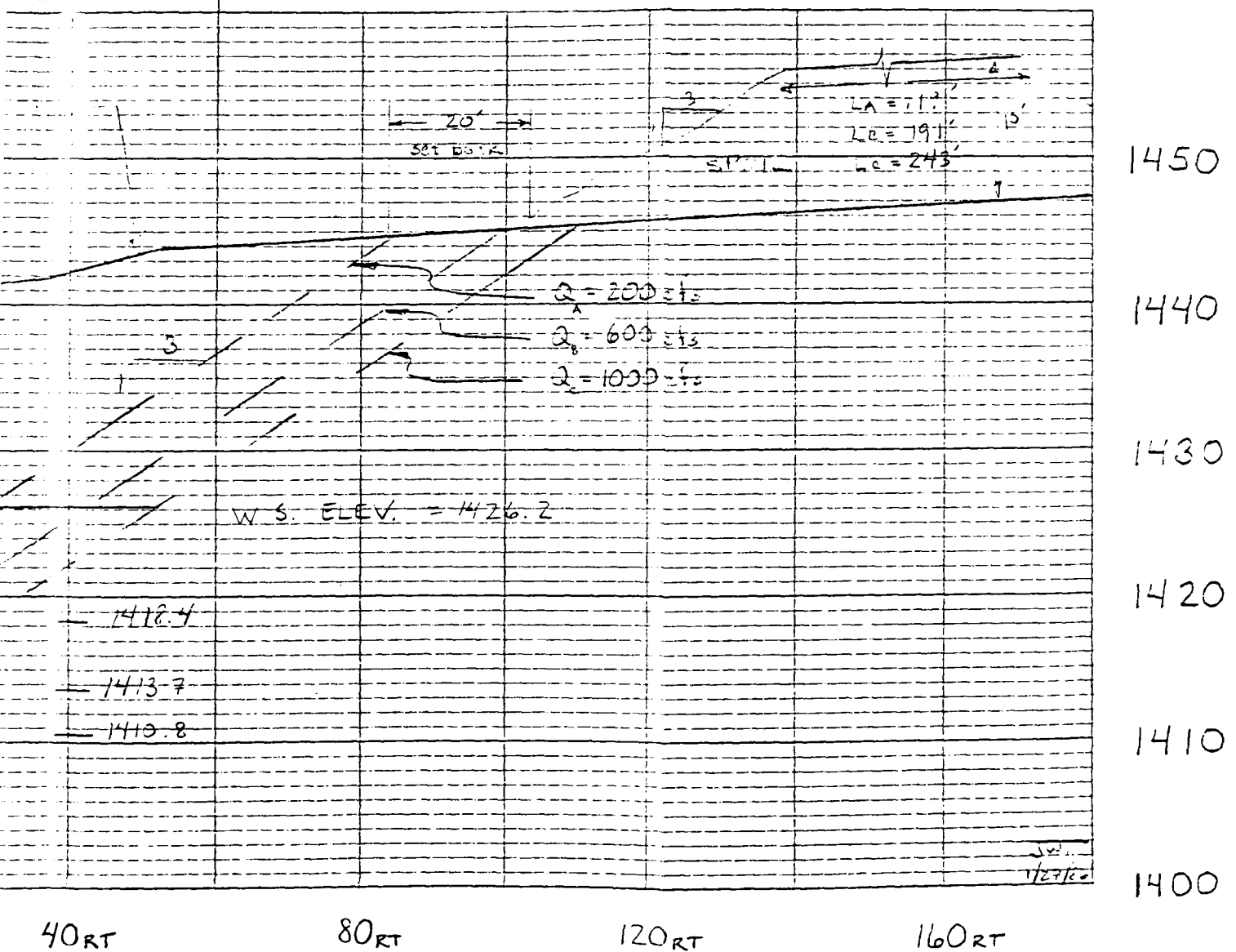
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 70+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 1A, B, & C  
CROSS SECTION STA 120+00



1450

(same as RT side)

ELEV 1450

1440

1430

W.S. ELEV 1426.4

1420

14.86

1410

1413.9

1411.0

1400

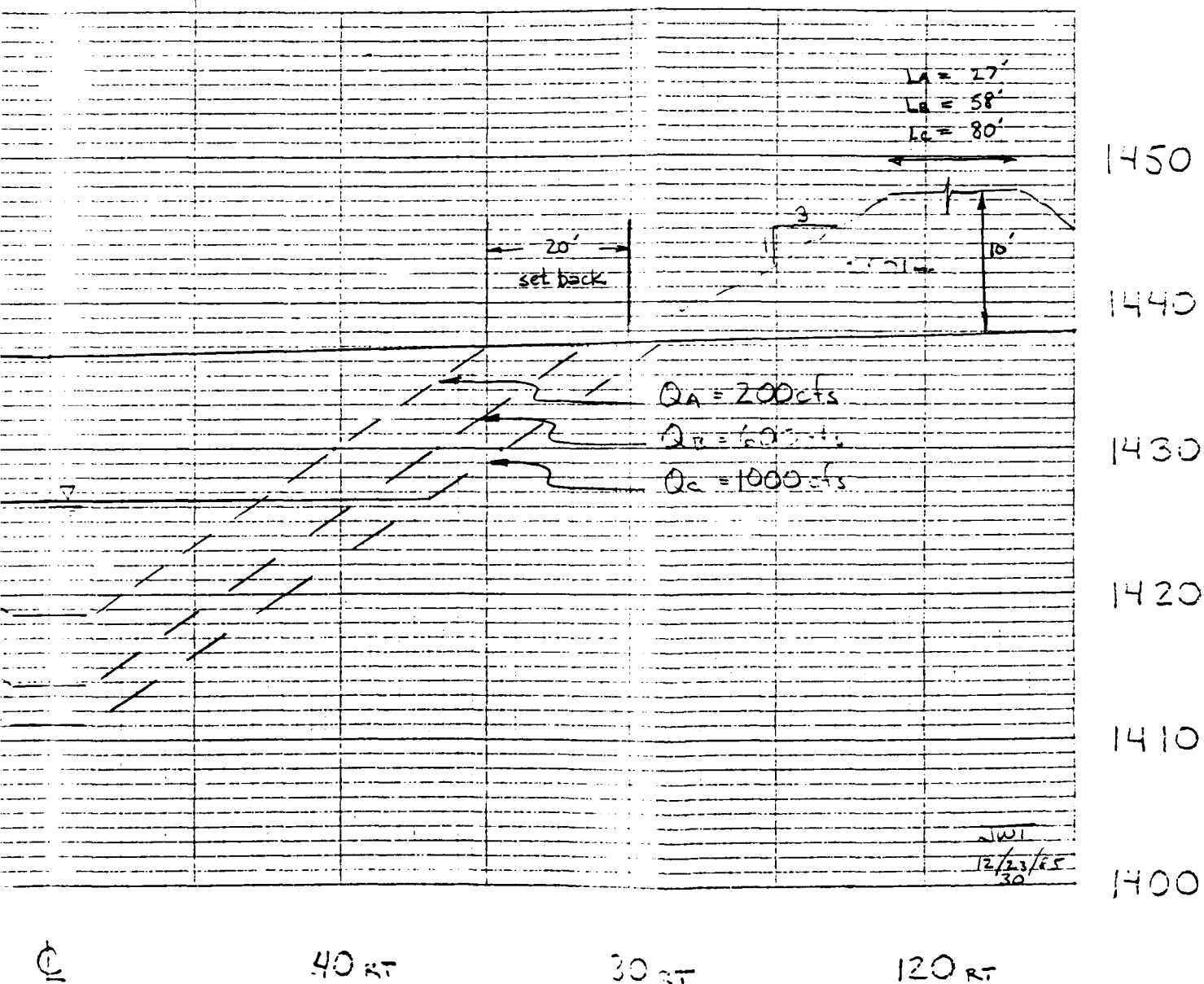
120 LT

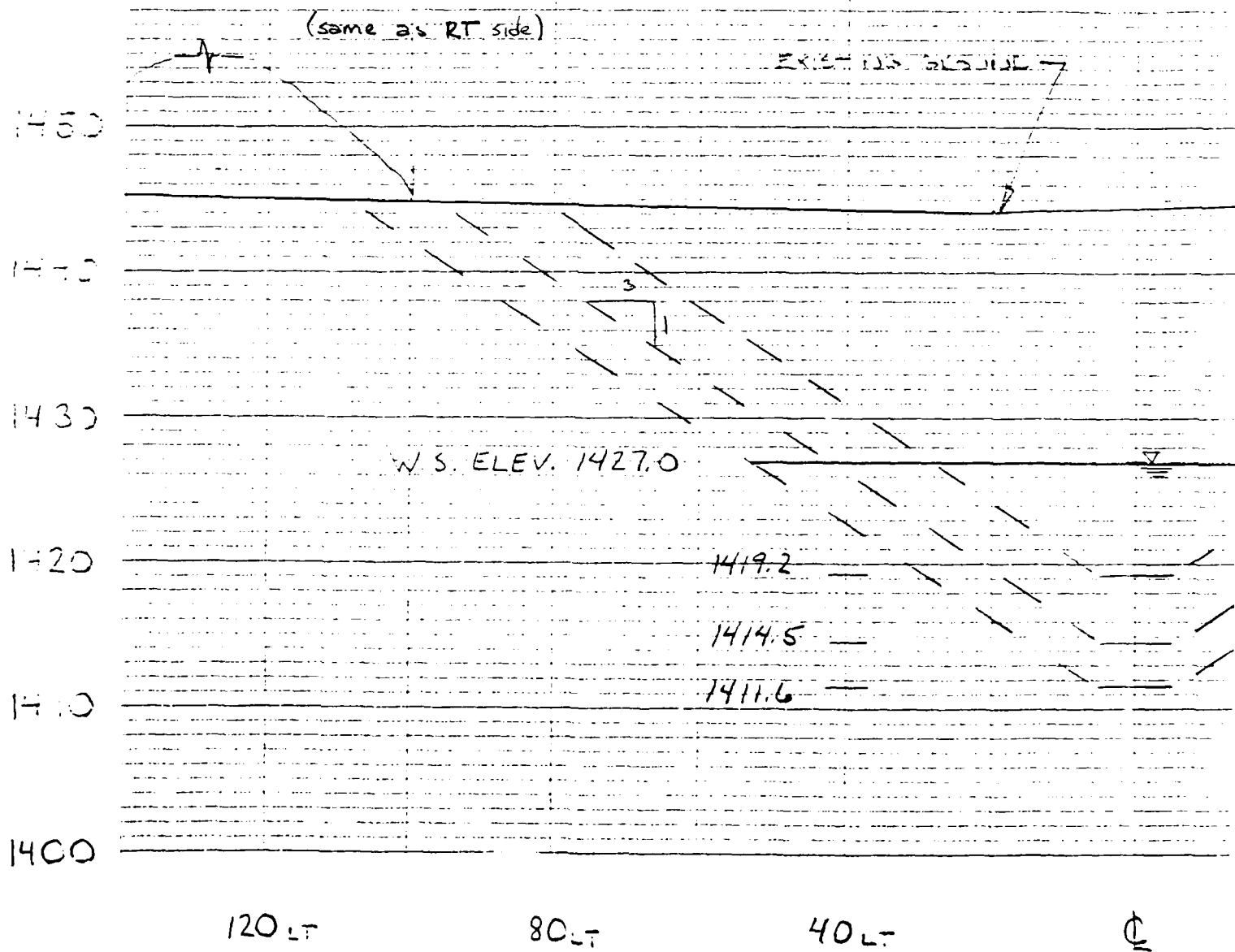
30 LT

40 LT

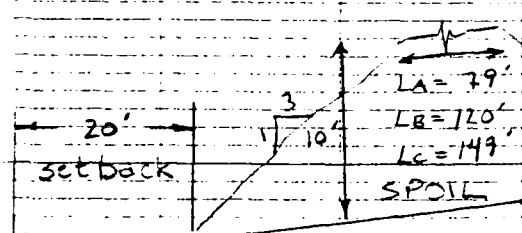
①

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 170+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 210+00



$$Q_A = 200 \text{ cfs}$$

$$Q_B = 600 \text{ cfs}$$

$$Q_C = 1000 \text{ cfs}$$

JW  
12/23/85

40 RT

80 RT

120 RT

1450

1440

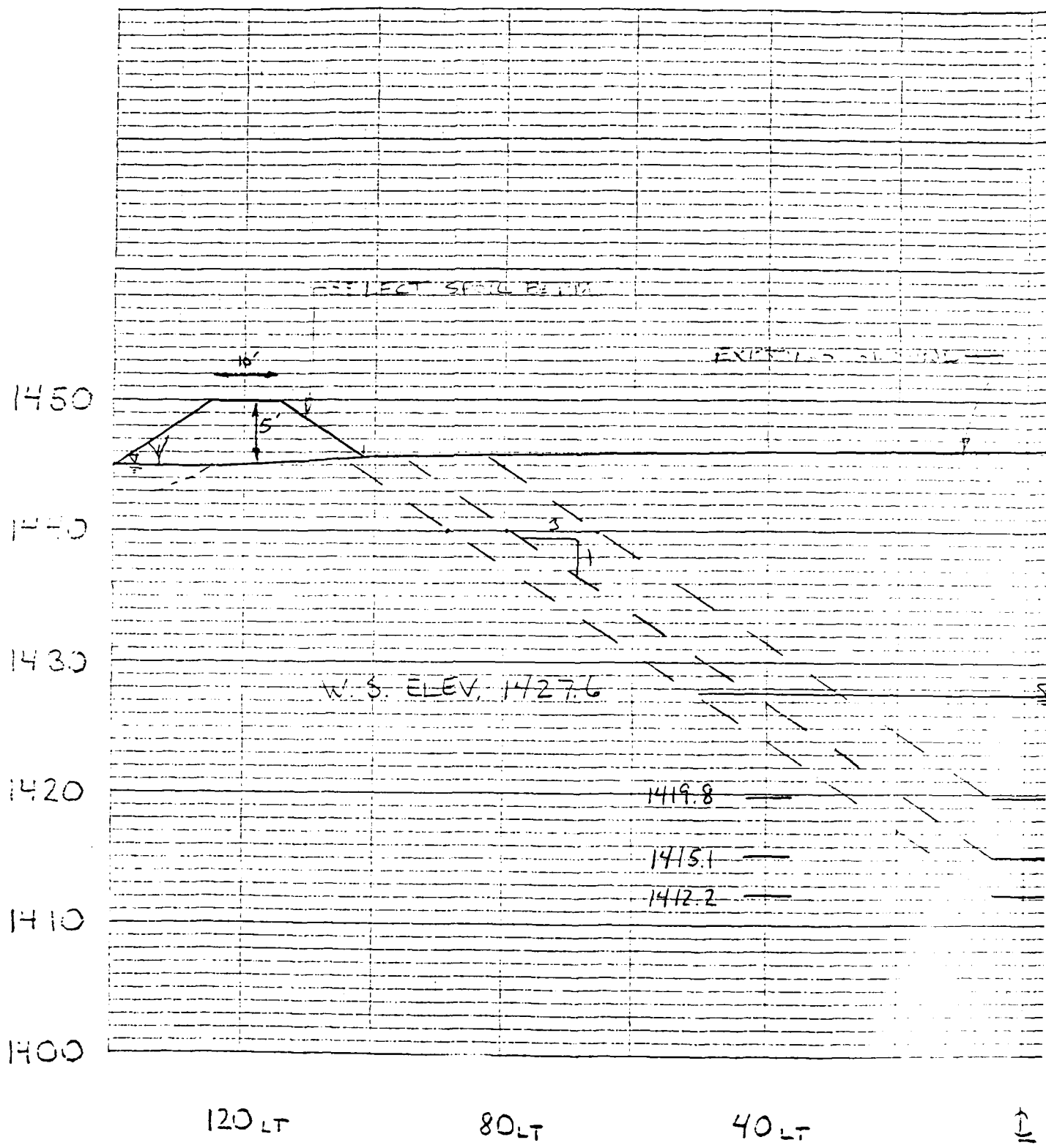
1430

1420

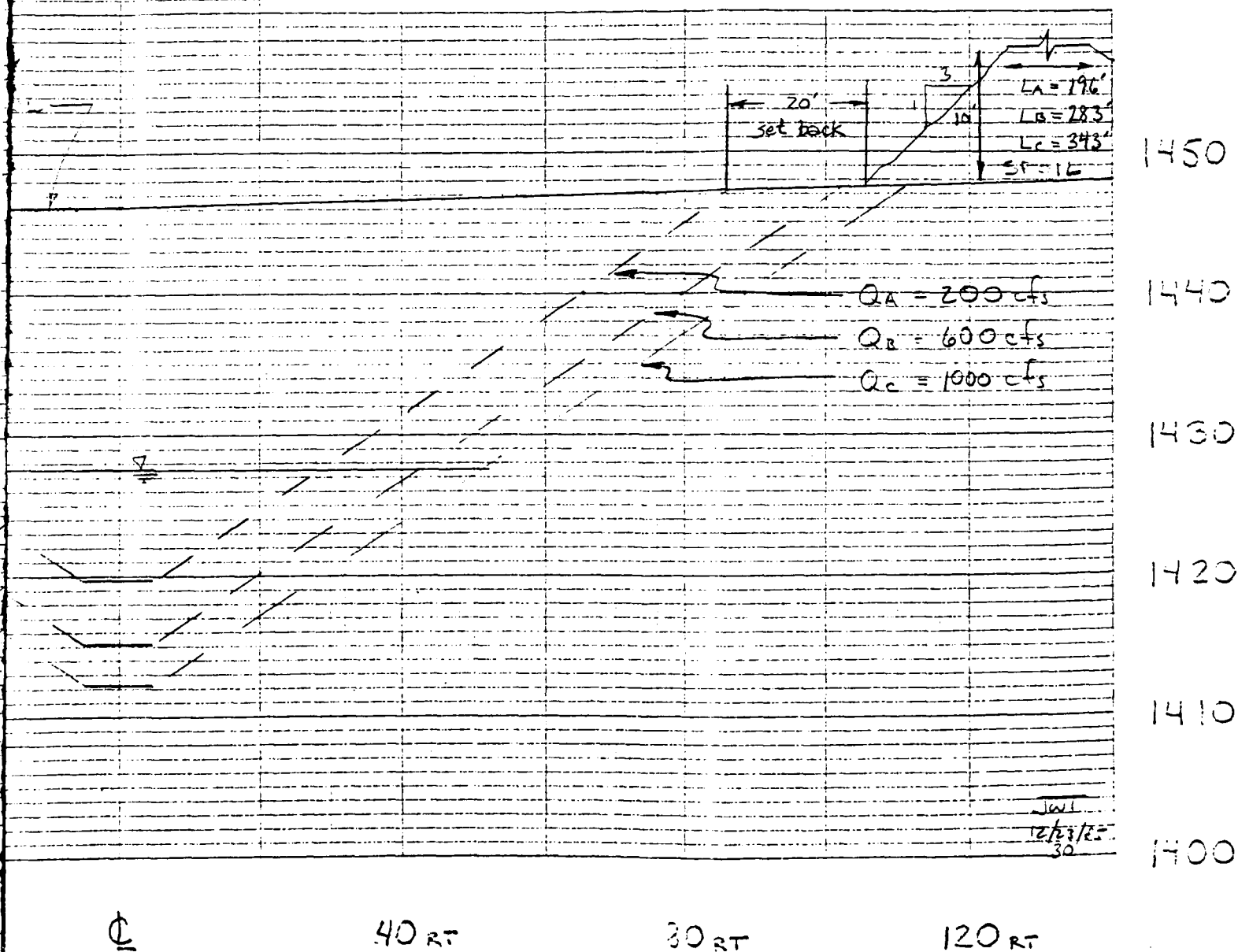
1410

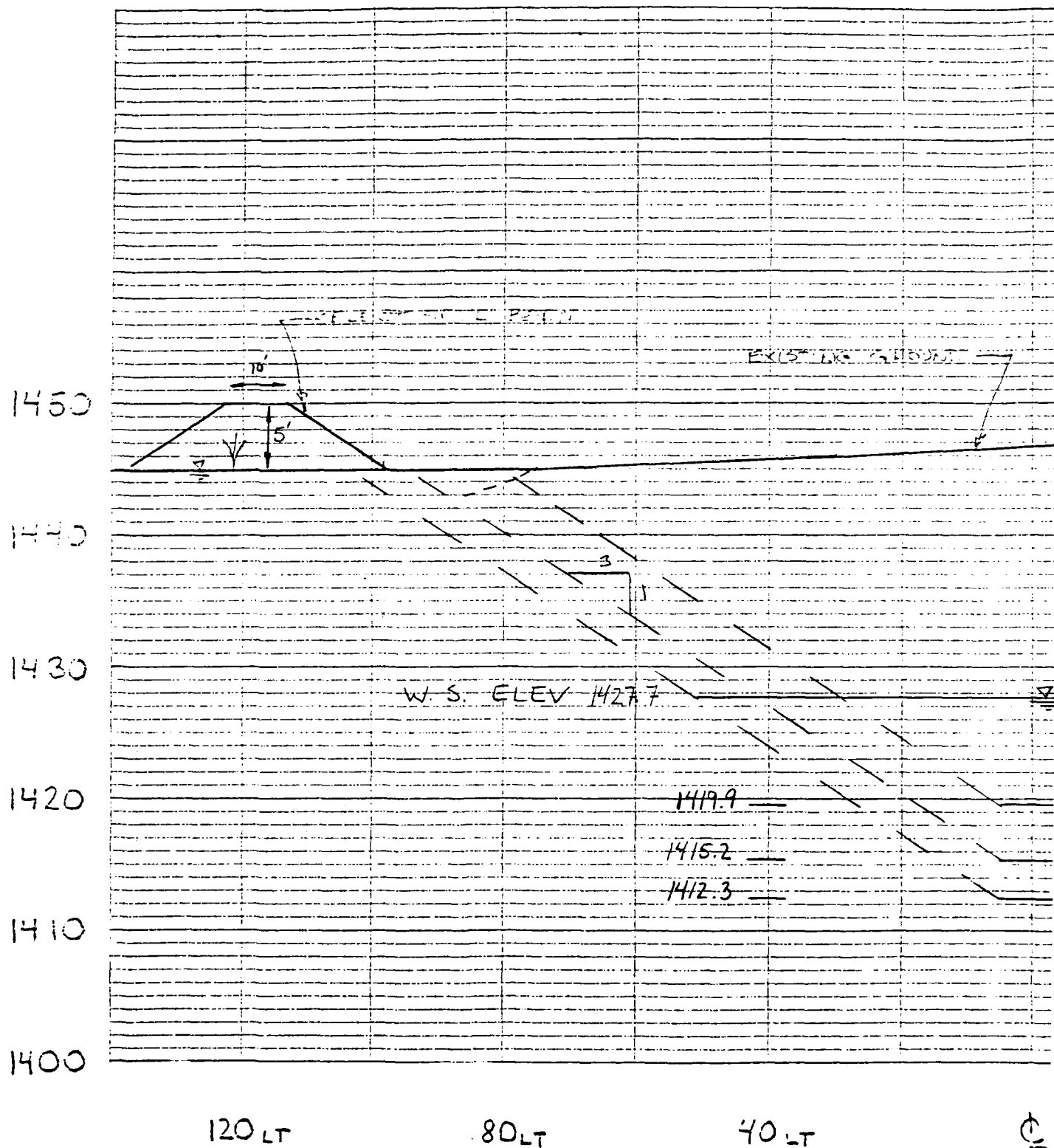
1400





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 244+00

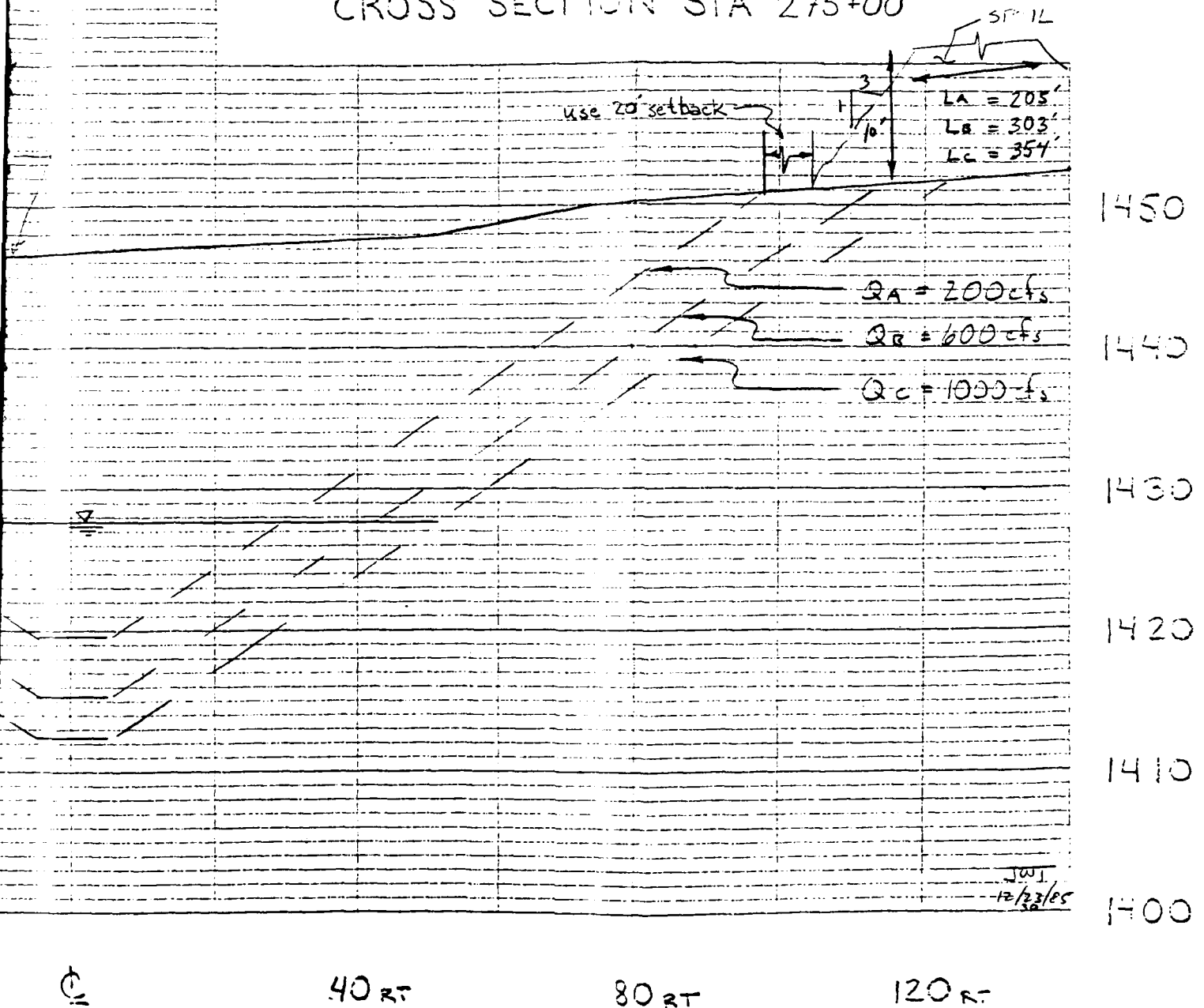


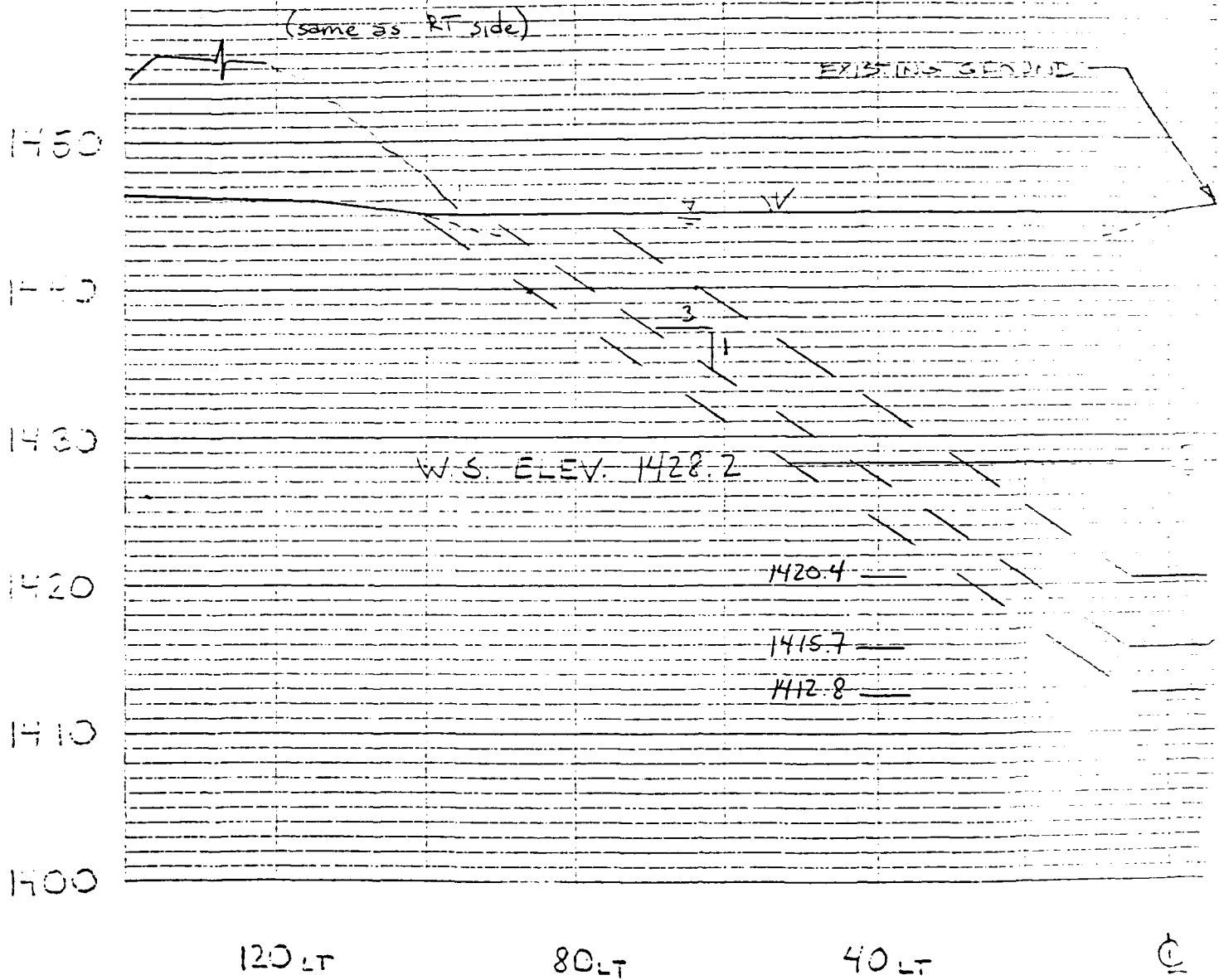


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

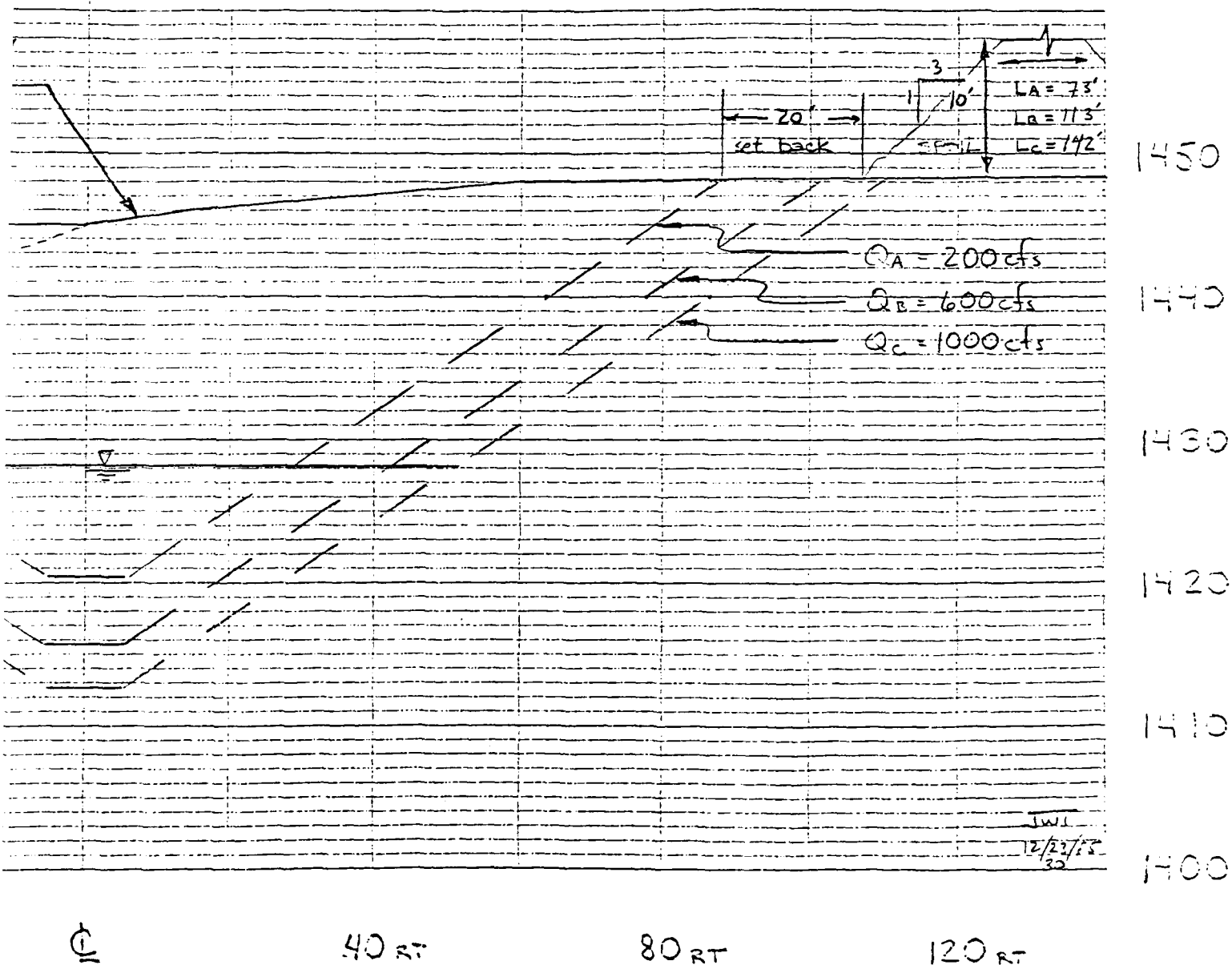
CASE 1 A, B, & C

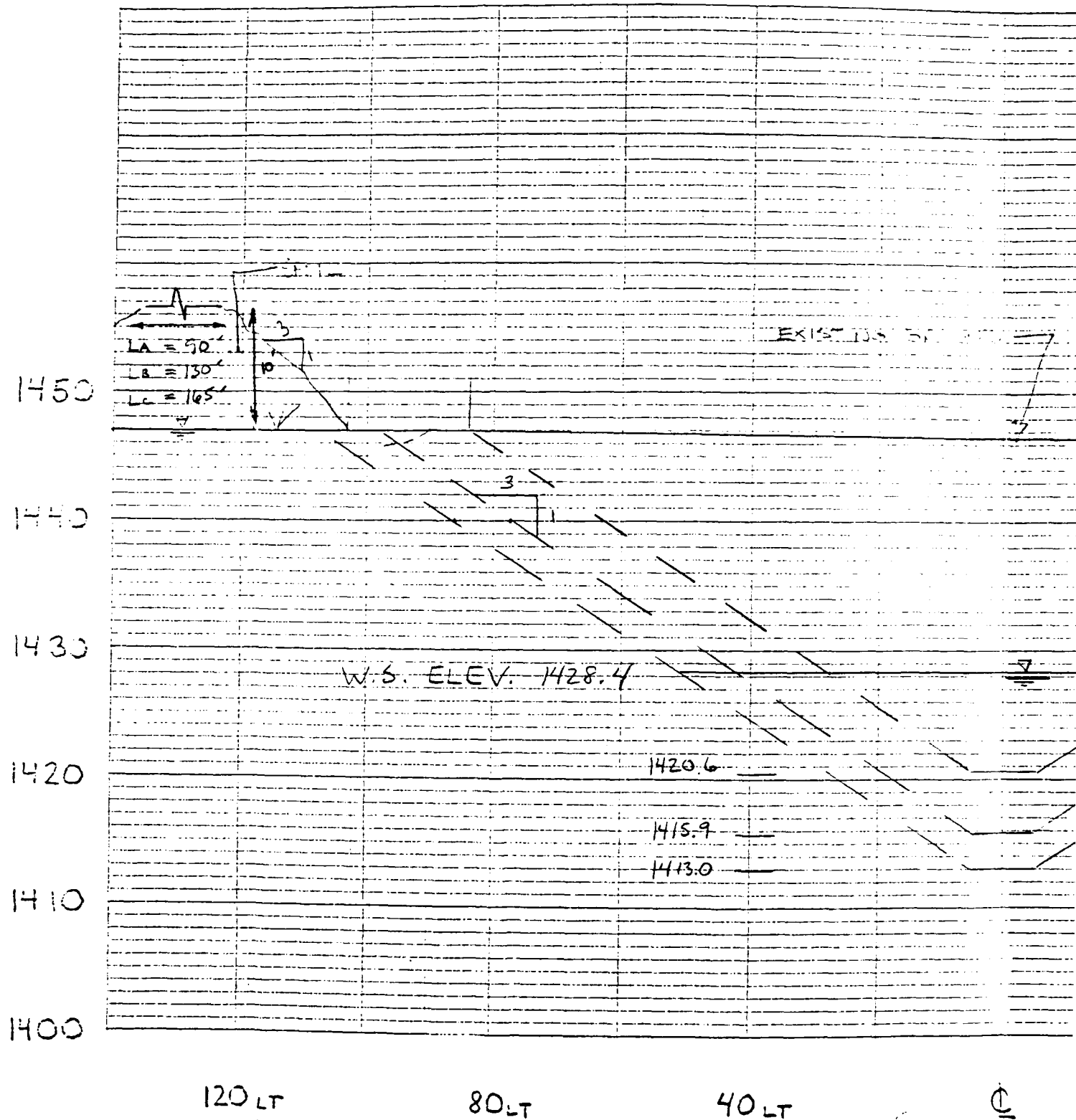
CROSS SECTION STA 275+00



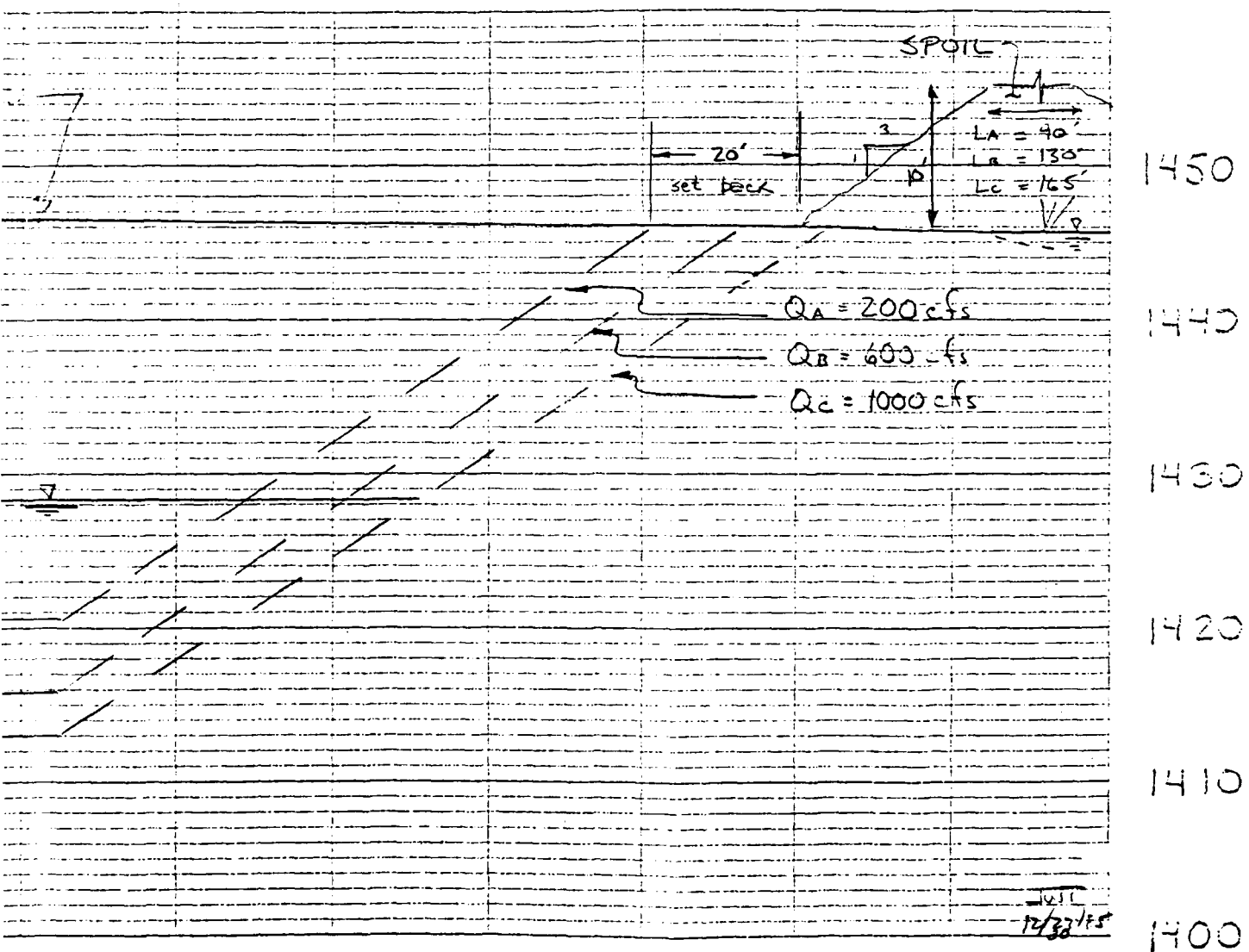


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1A, B, & C  
CROSS SECTION STA 304+00





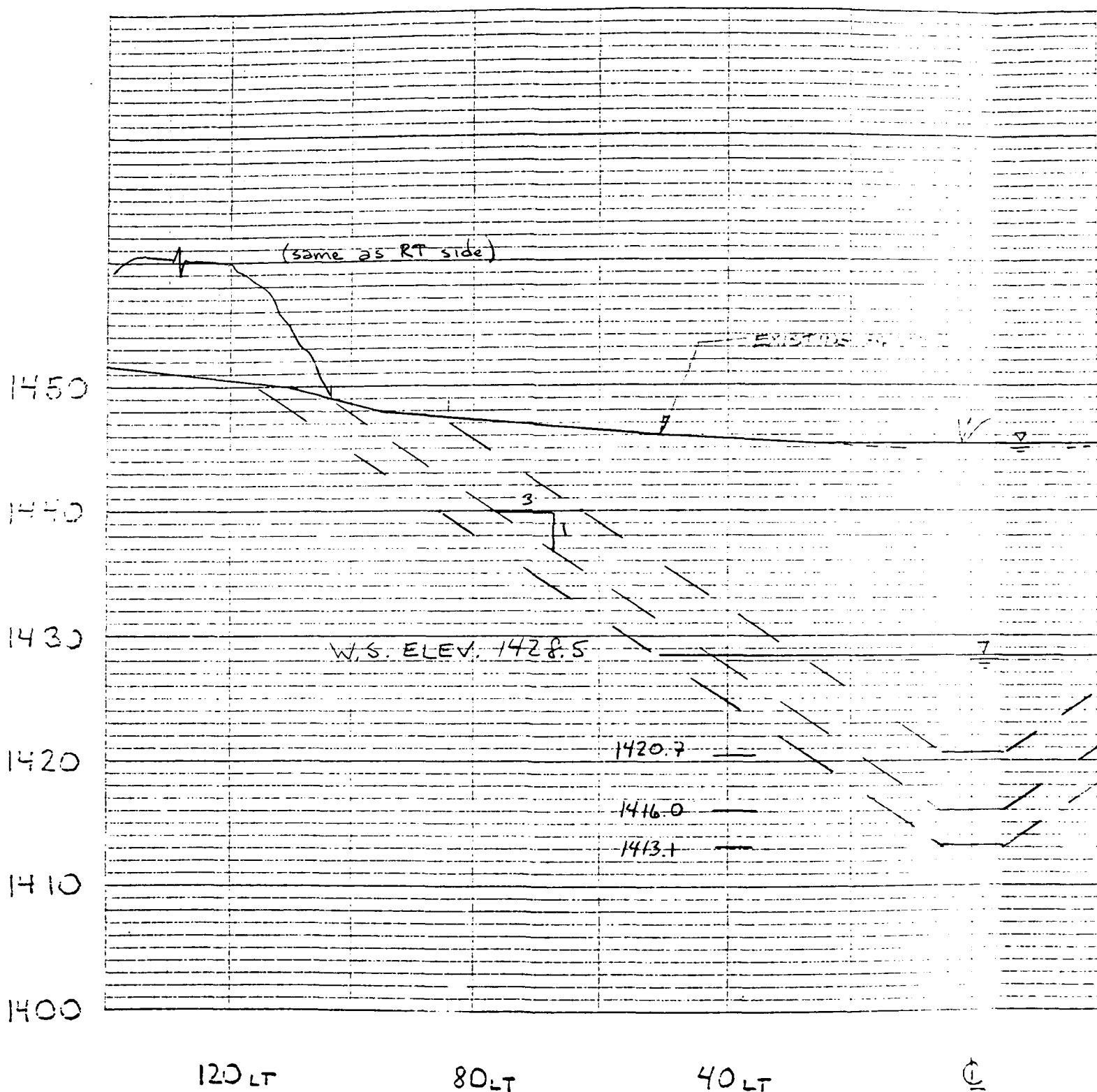
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 345+00



2

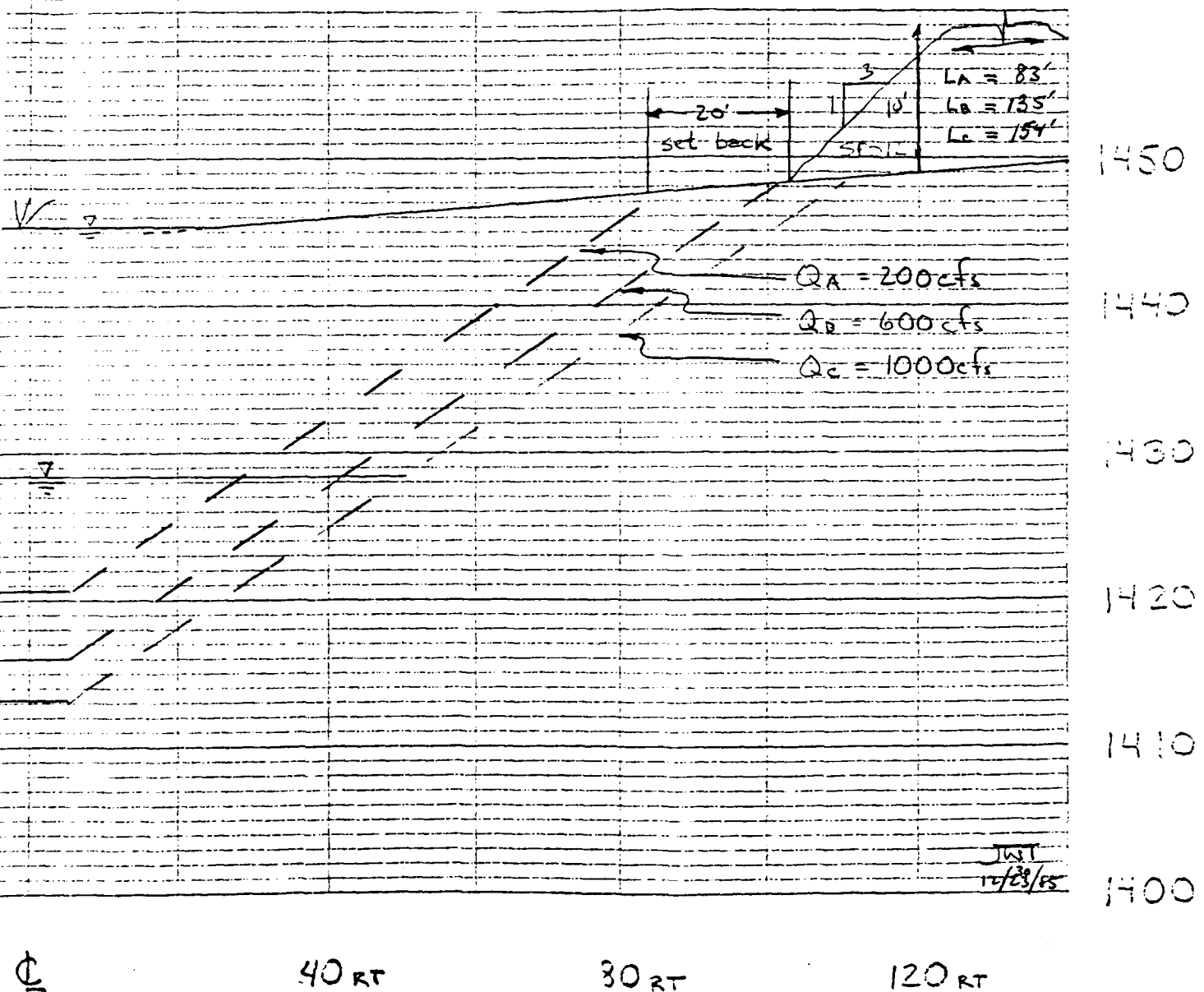
PLAN C-2

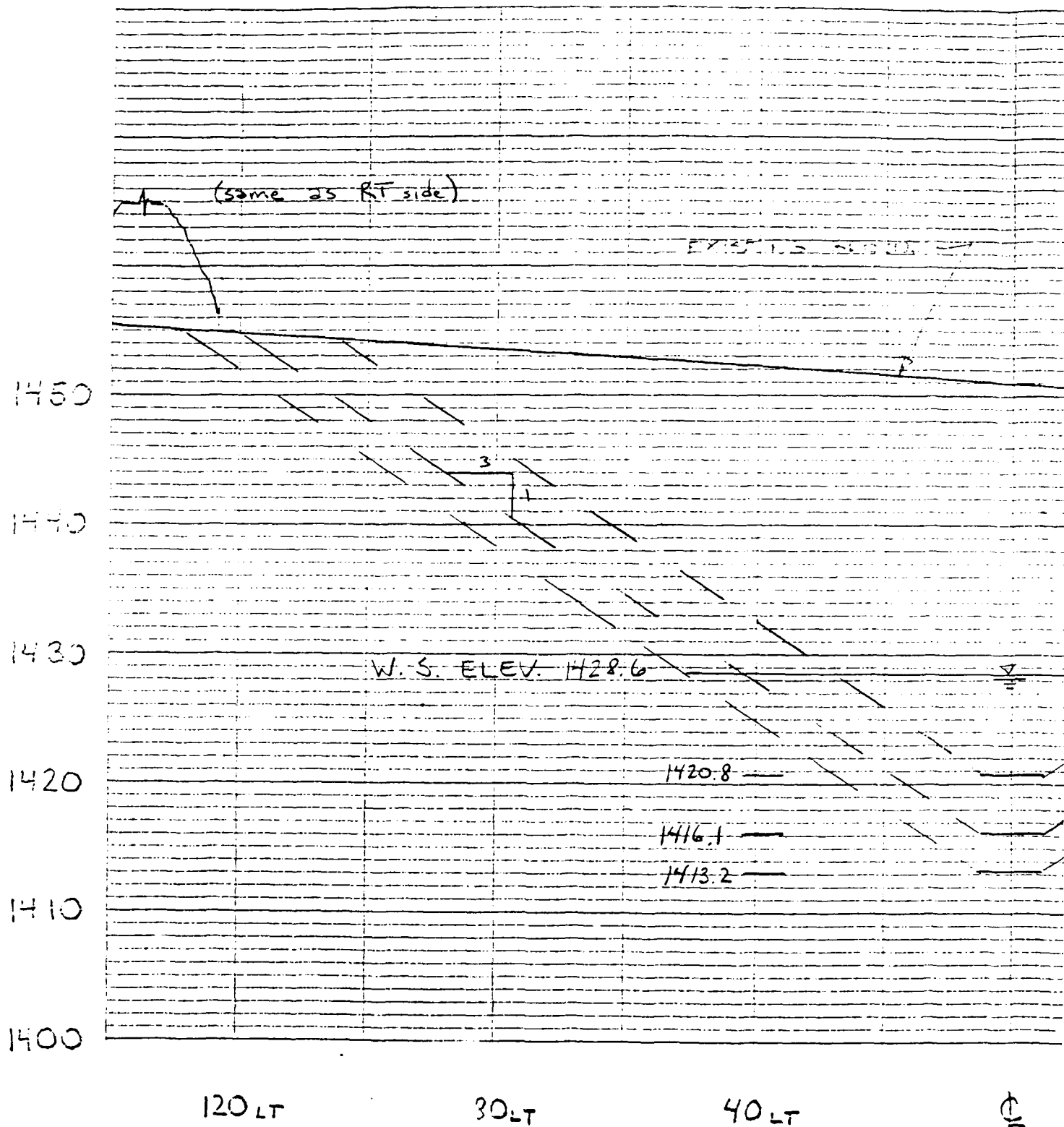




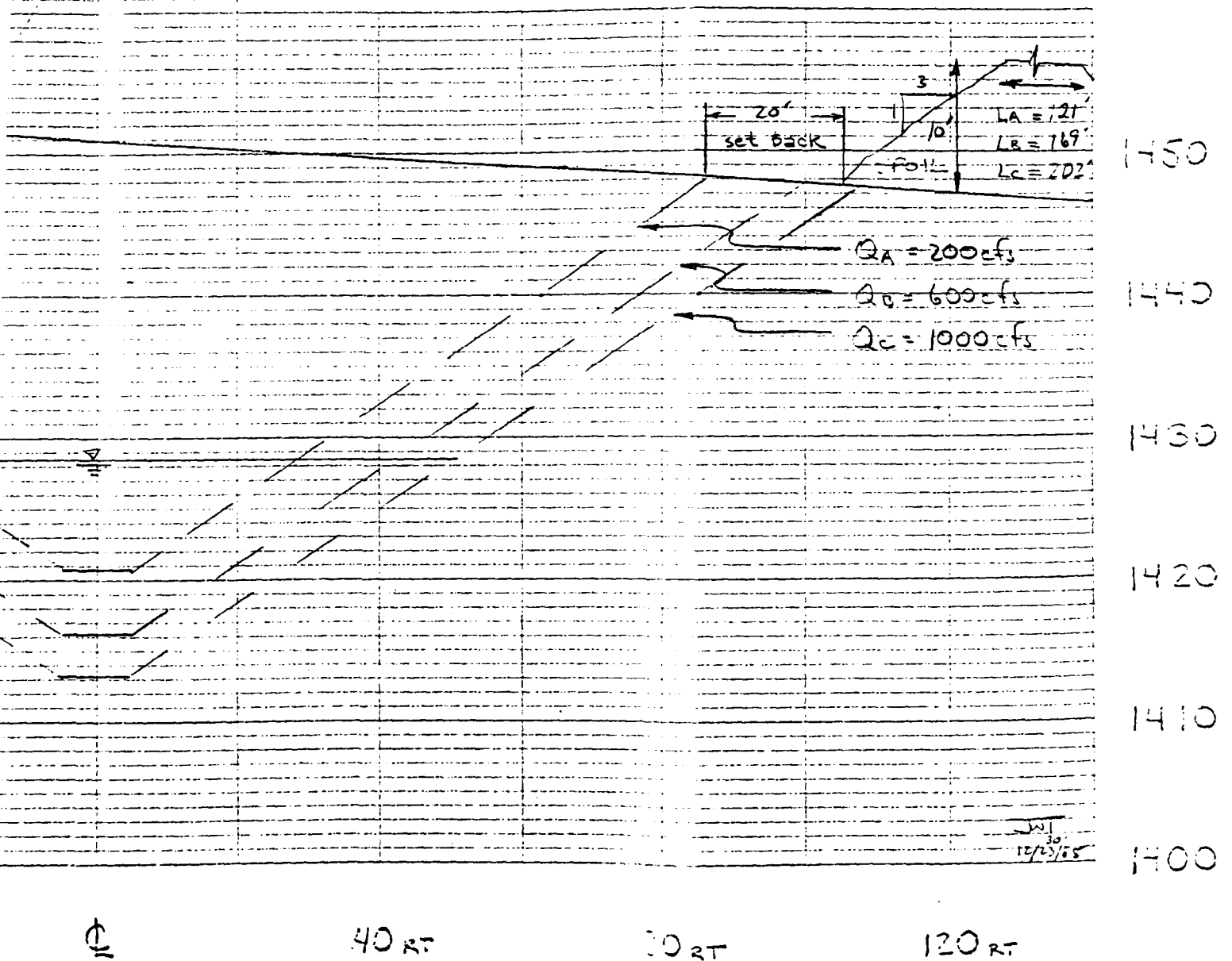
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

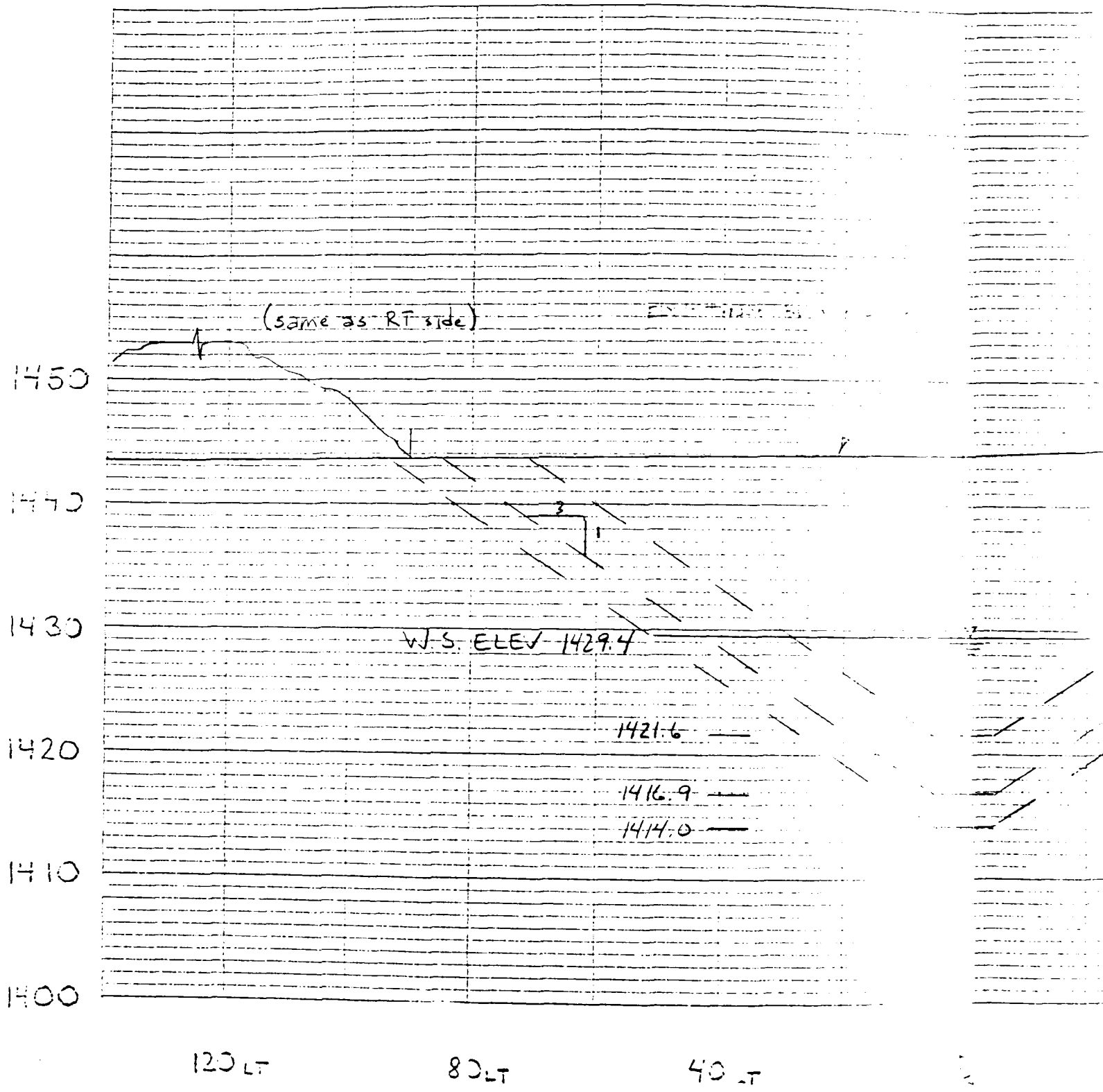
CASE 1 A, B, & C  
CROSS SECTION STA 370+00



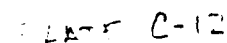


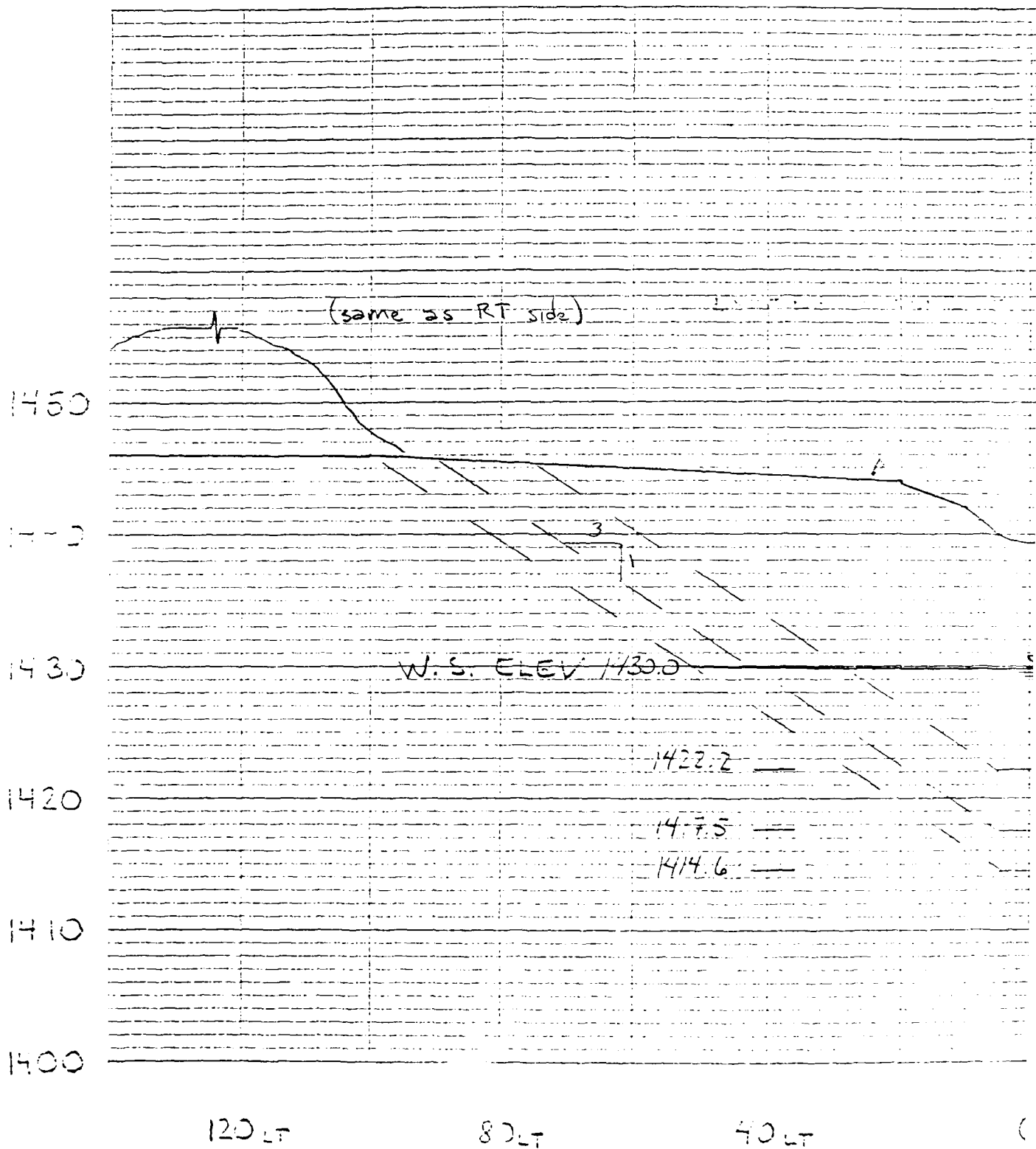
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 398+00



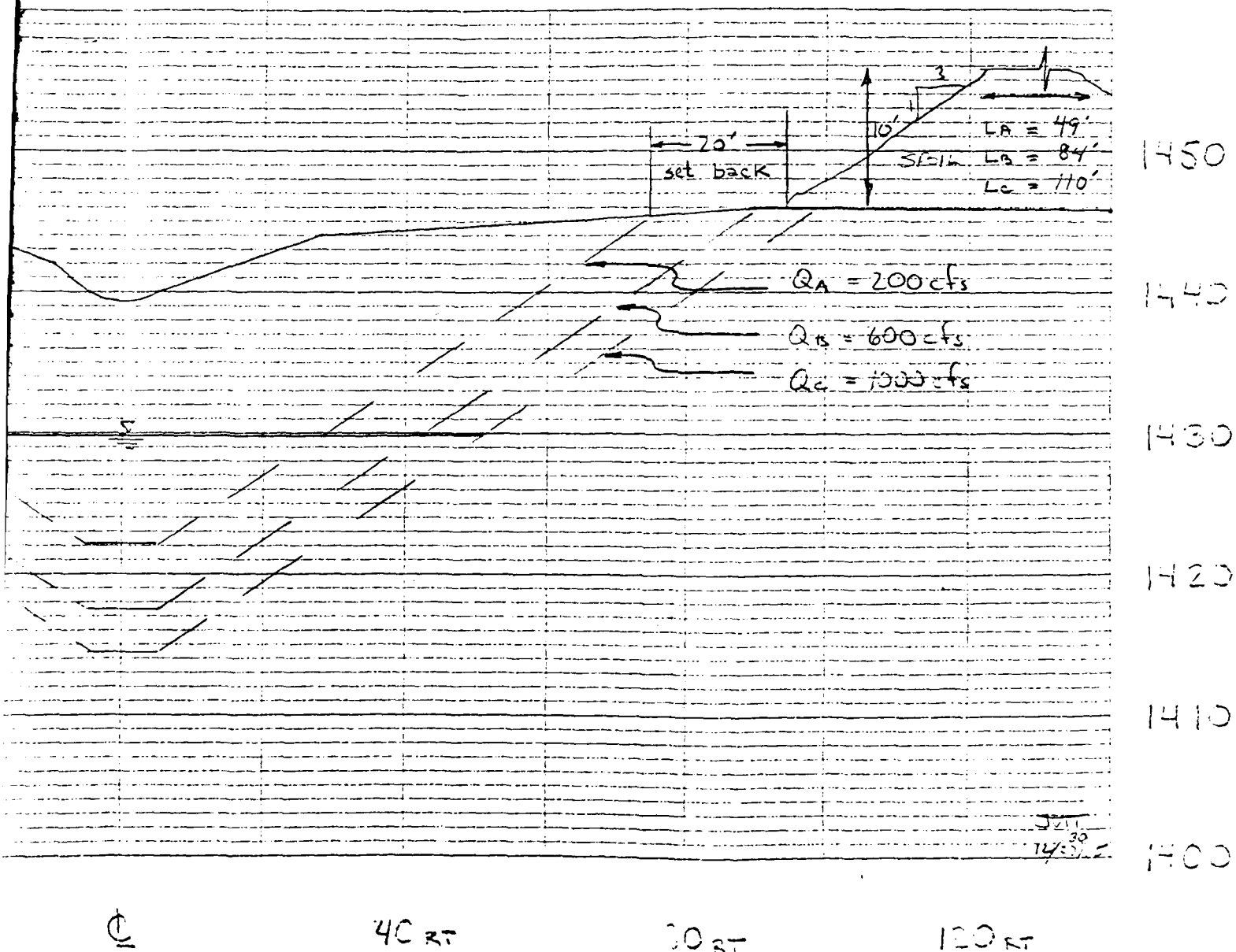


CASE 1 A, B, & C  
CROSS SECTION STA 485+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 1 A, B, & C  
CROSS SECTION STA 514+00



1

2



1450

1440

1430

1420

1410

1400

(SAME AS LT SIDE)

17.0% 340.0'

W.S. ELEV 1410.2

120<sub>LT</sub>

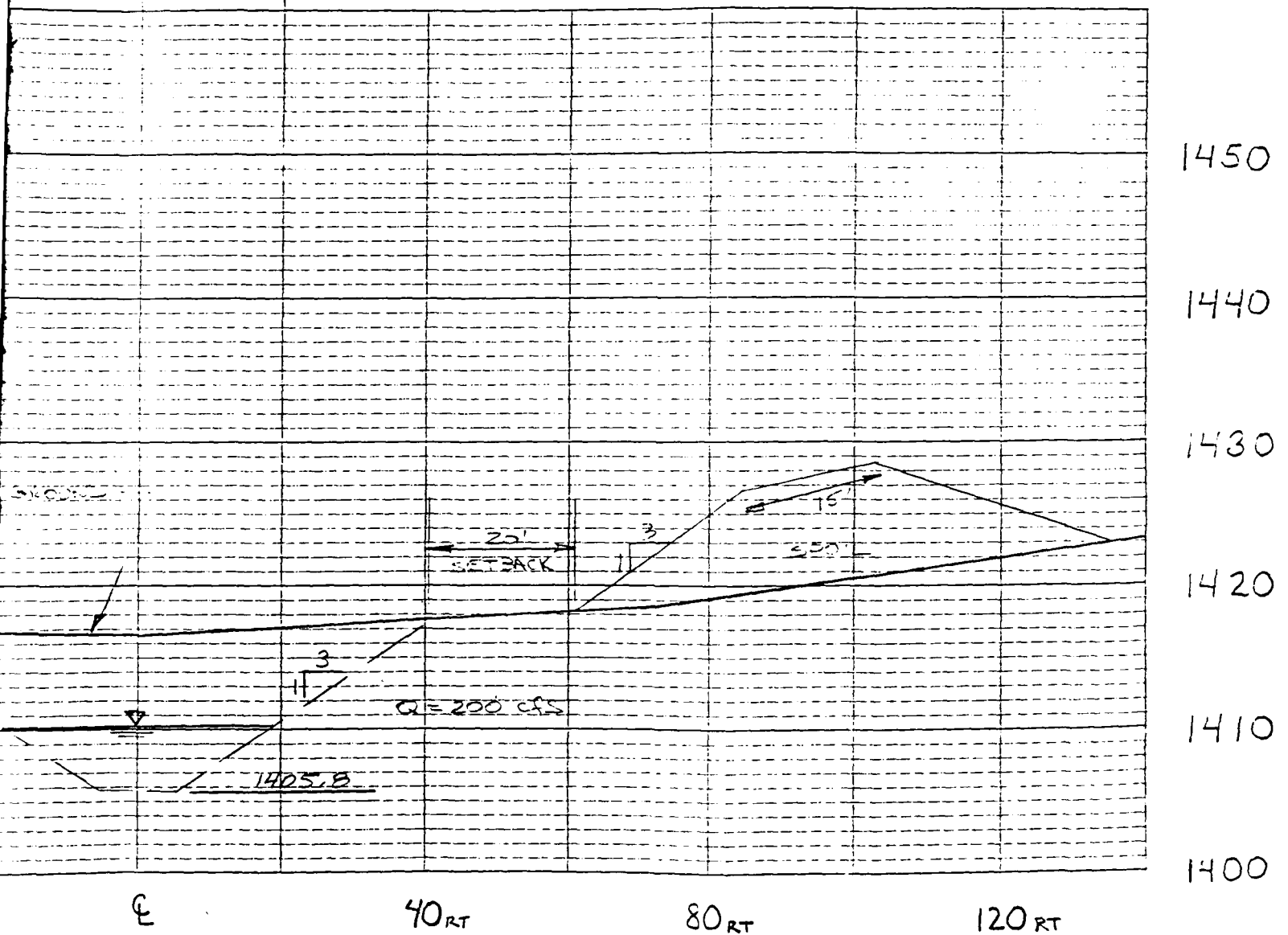
80<sub>LT</sub>

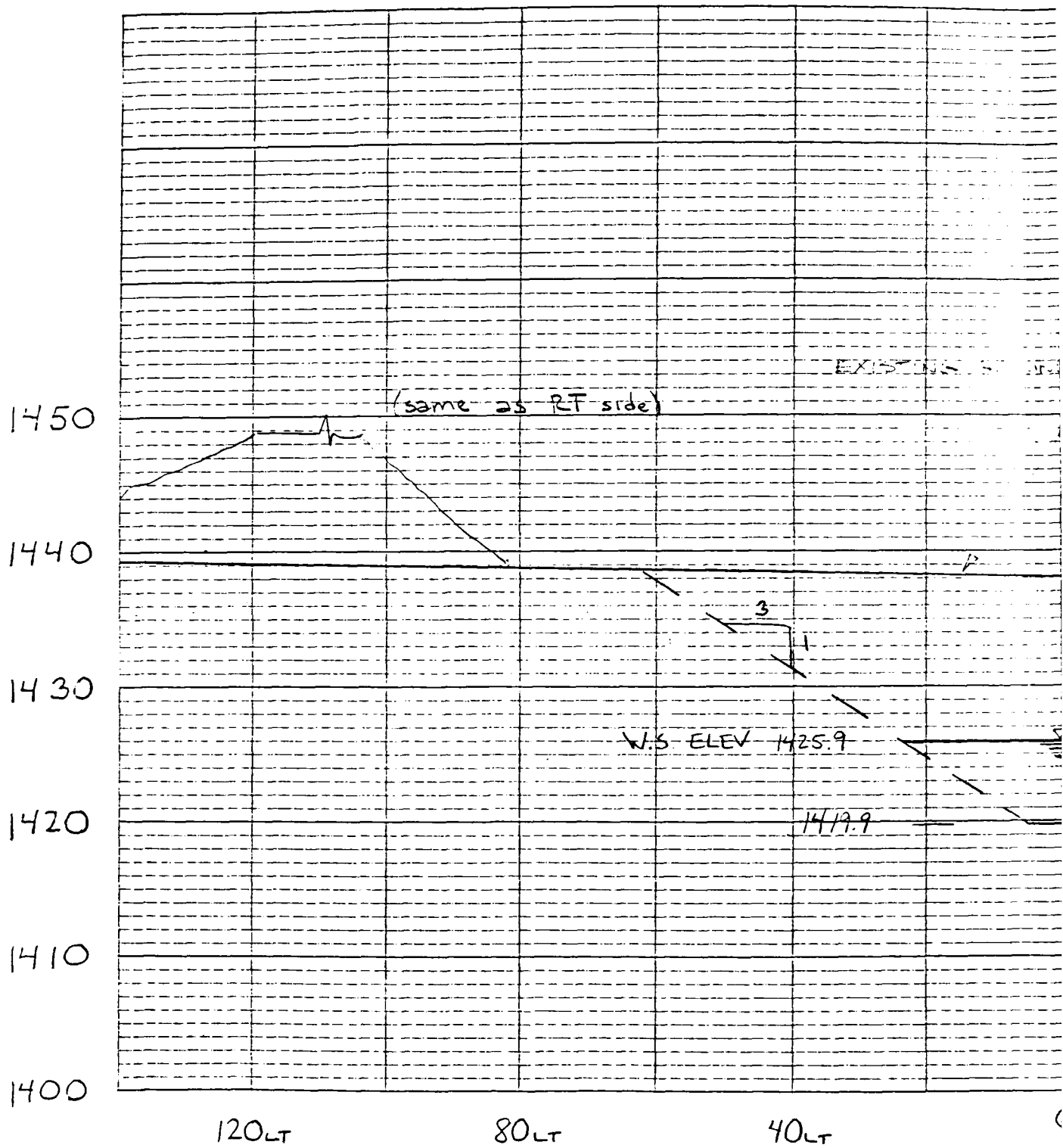
40<sub>LT</sub>

℄

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE 24  
CROSS SECTION STA 25+00



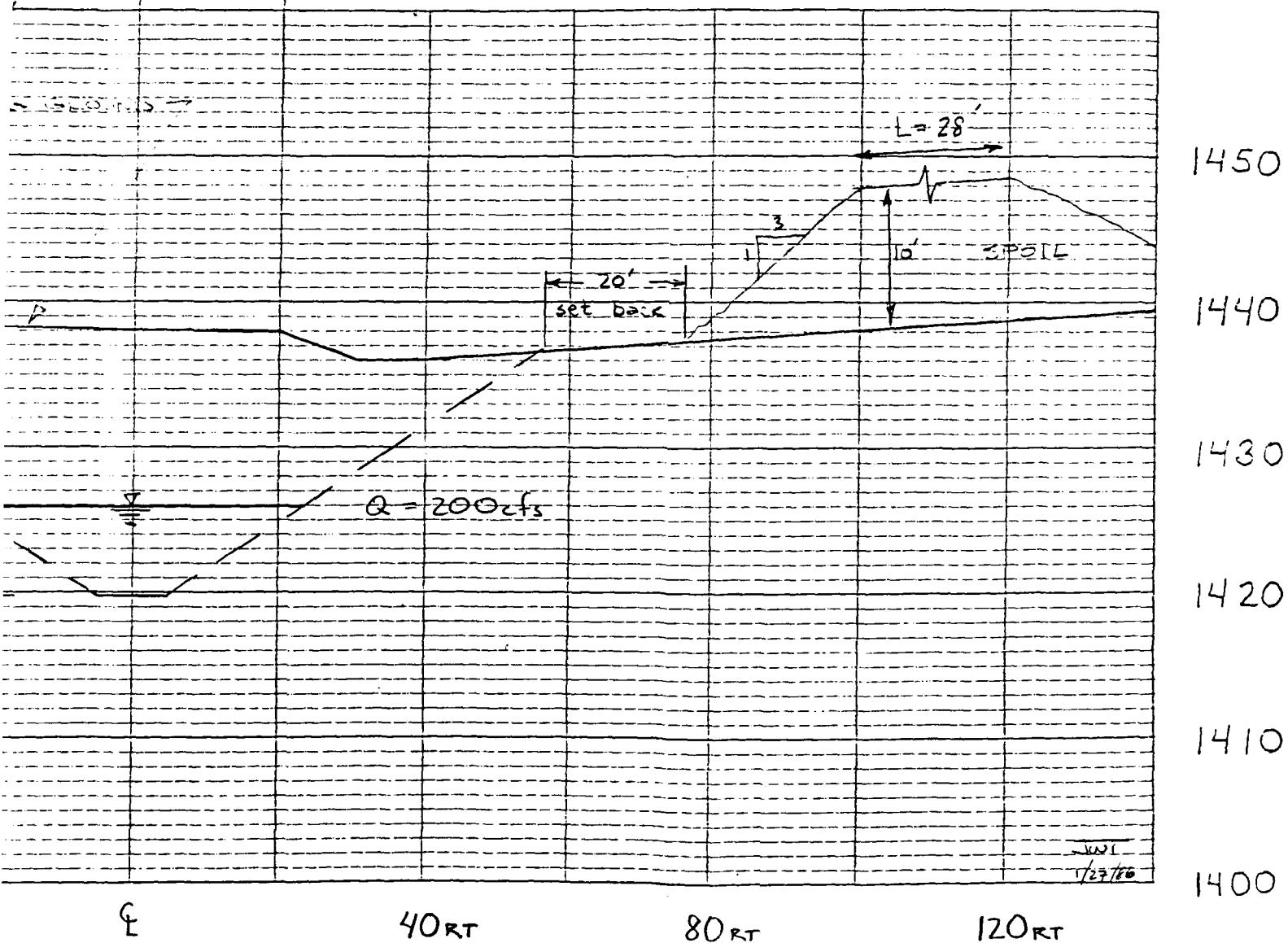


120LT

80<sub>LT</sub>

40LT

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 2G  
CROSS SECTION STA 70+00



1450

1440

1430

1420

1410

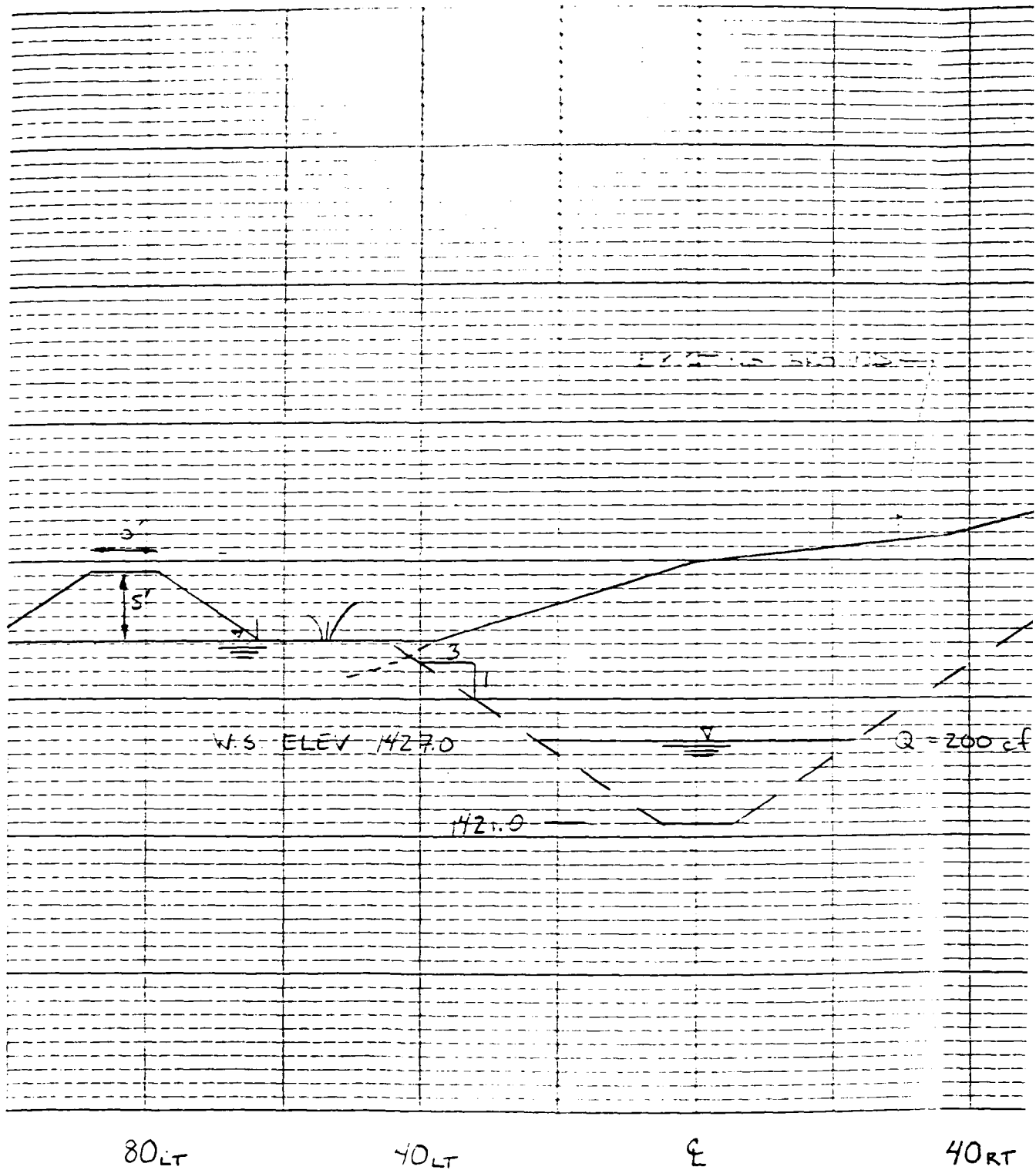
1400

80<sub>LT</sub>

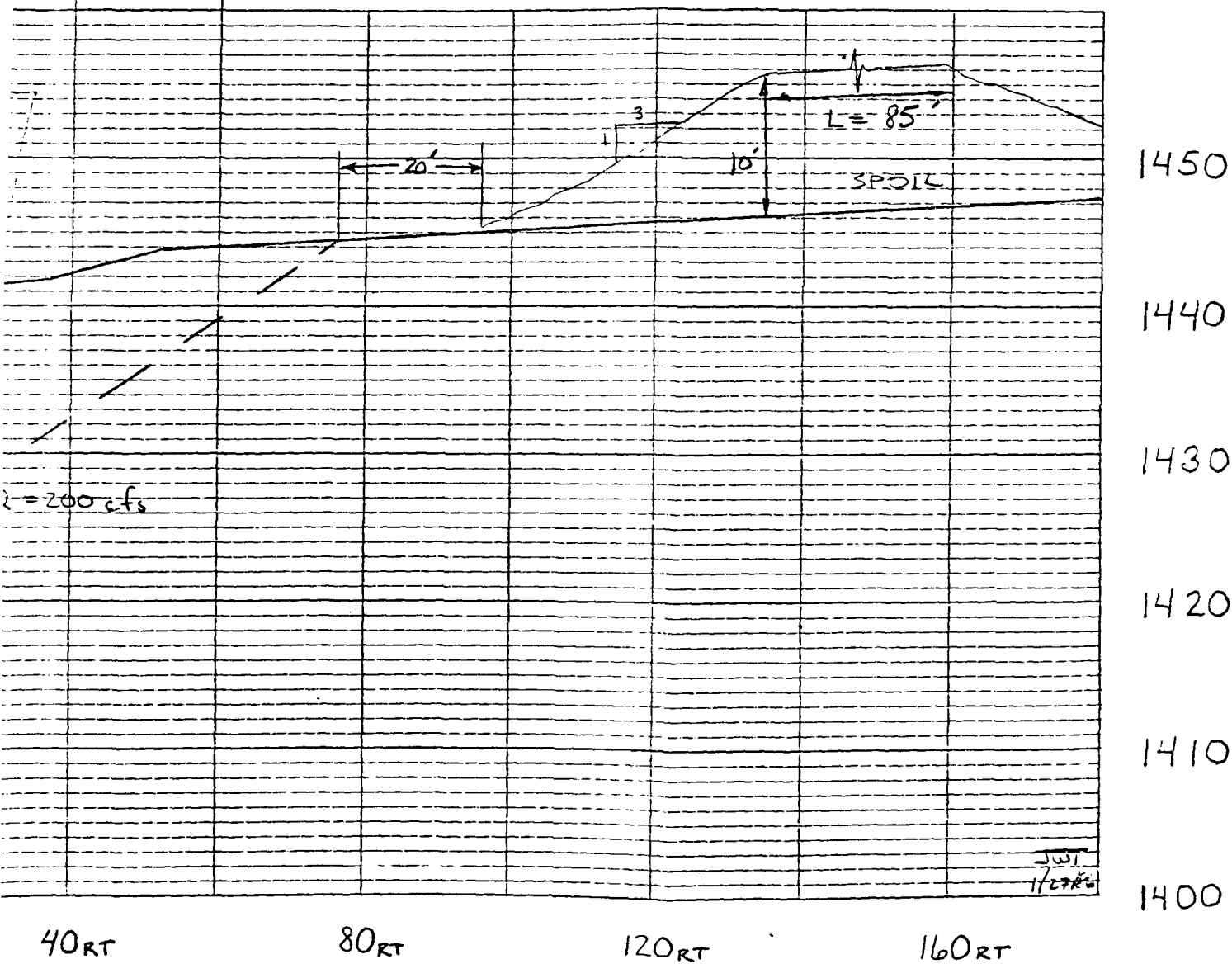
40<sub>LT</sub>

℄

40<sub>RT</sub>



# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 2G CROSS SECTION STA 120+00



1450

(same as RT side)

1440

1430

1420

1410

1400

120 LT

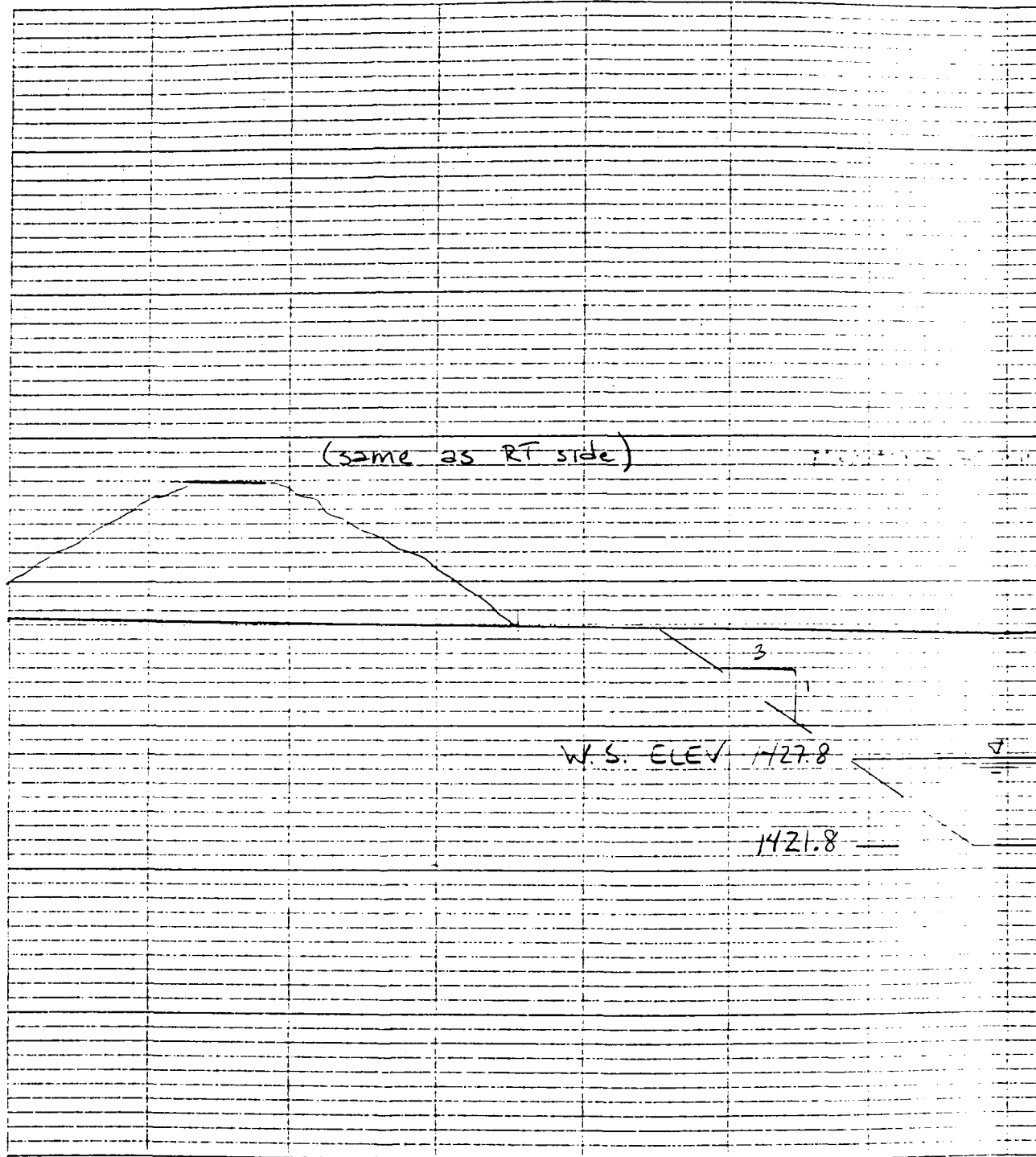
30 LT

40 LT

0

W.S. ELEV 1427.8

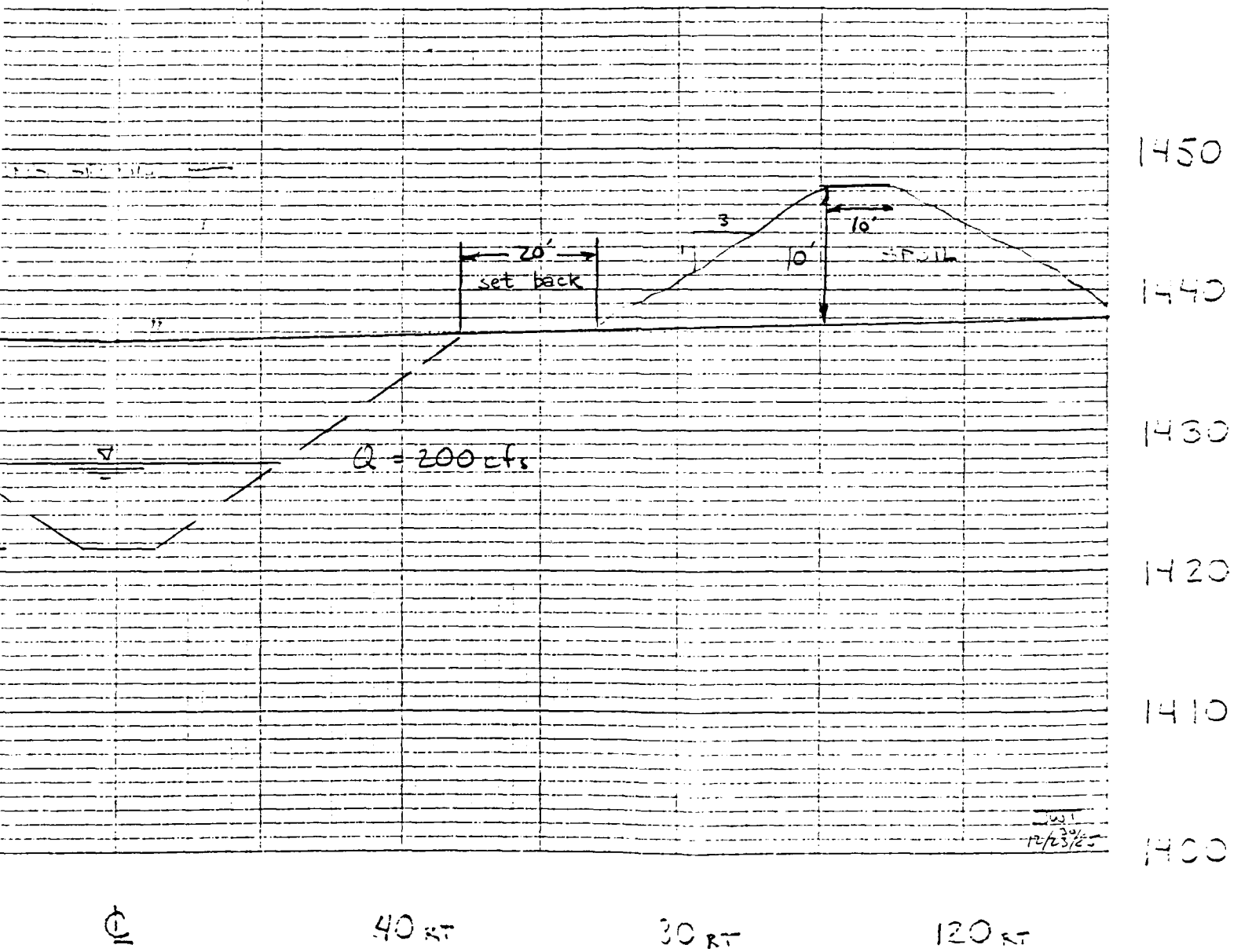
1421.8



# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2G

CROSS SECTION STA 170+00





1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 2679, 26

— 1 —

- 30 -

- 20 -

1-3

1400

W.S. ELEV. 1723.8

428

120 :-

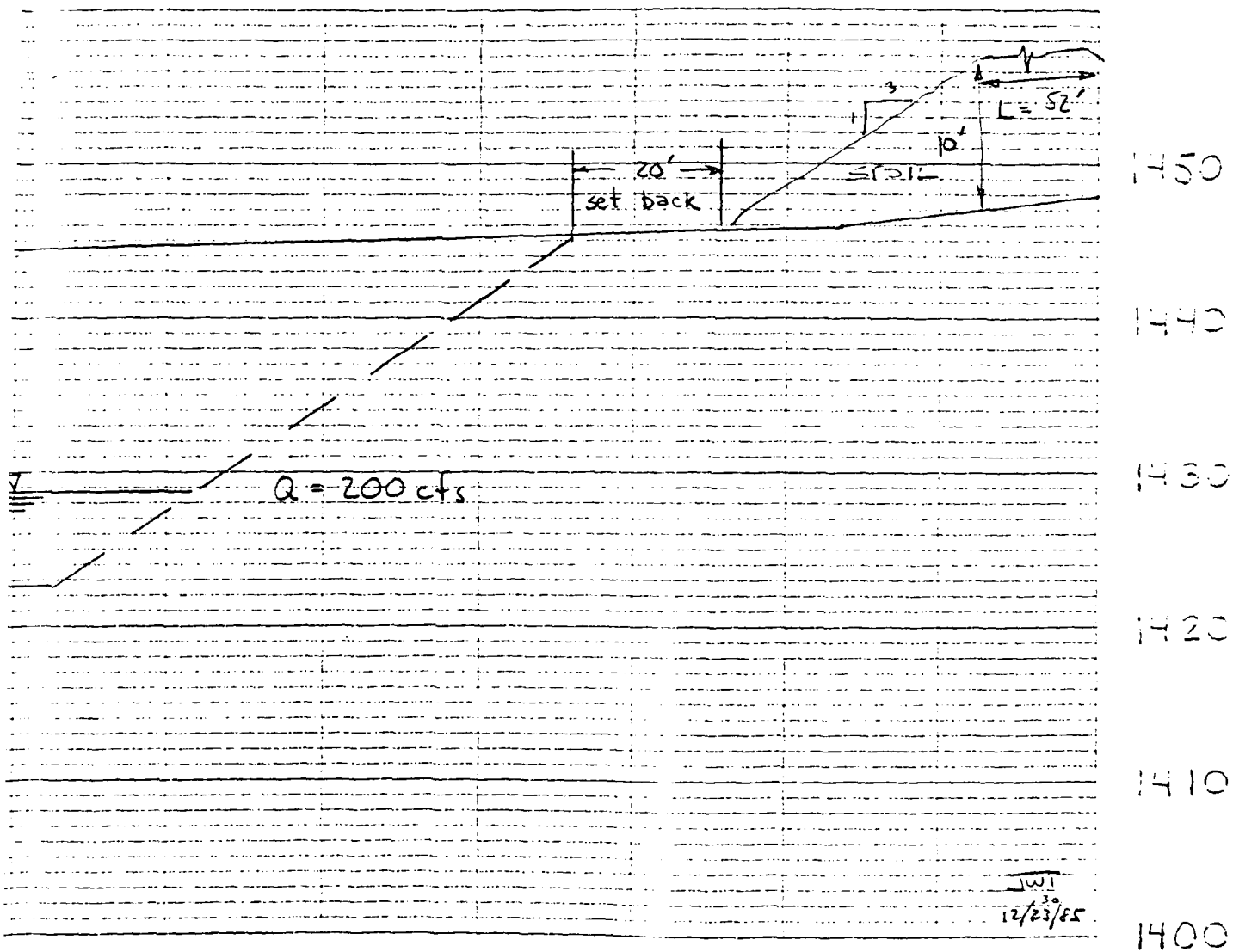
8C-7

405

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2G

CROSS SECTION STA 210+00



1

40 RT

80 RT

120 RT

1450

1440

1430

1420

1410

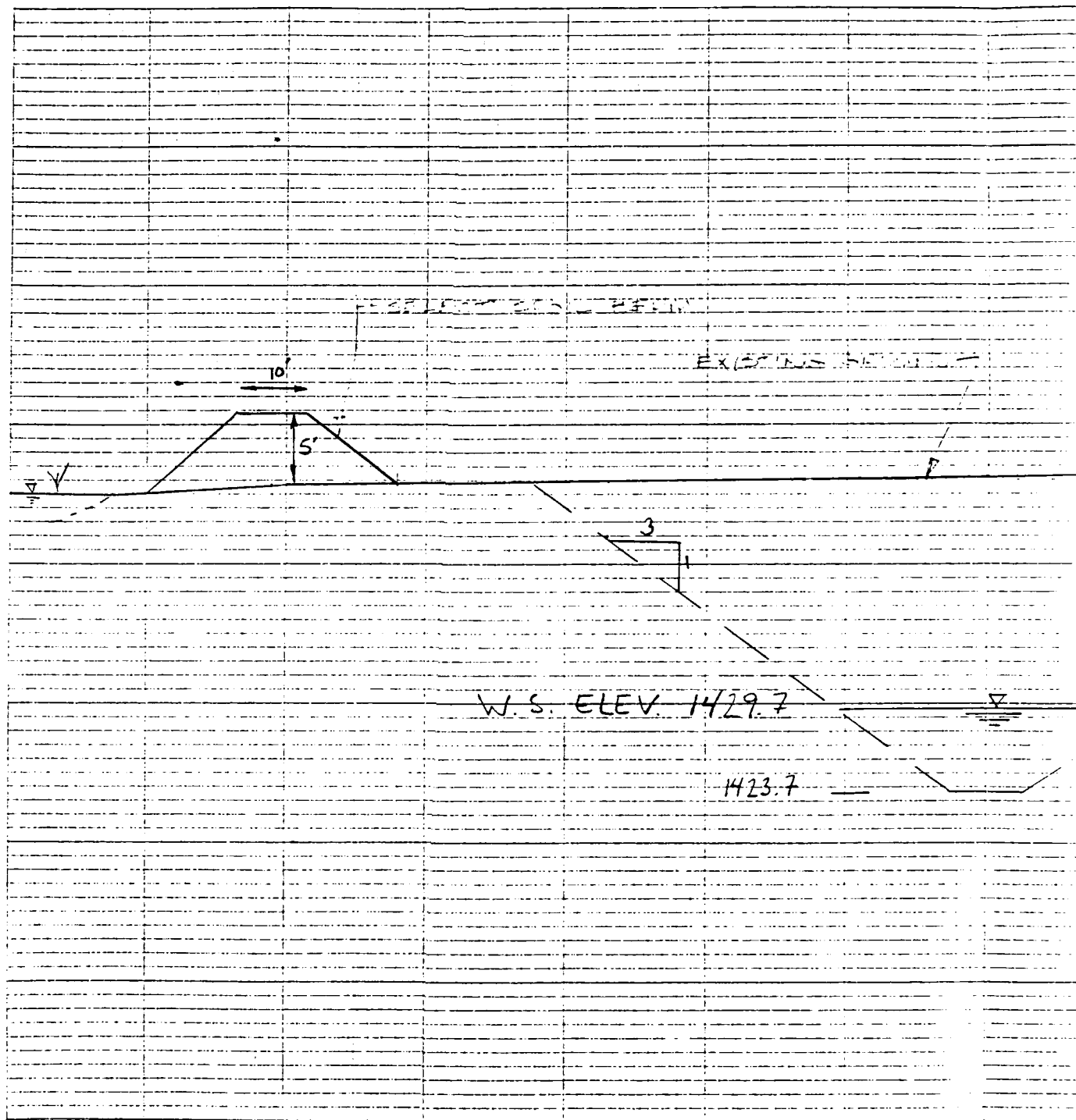
1400

120 LT

80 LT

40 LT

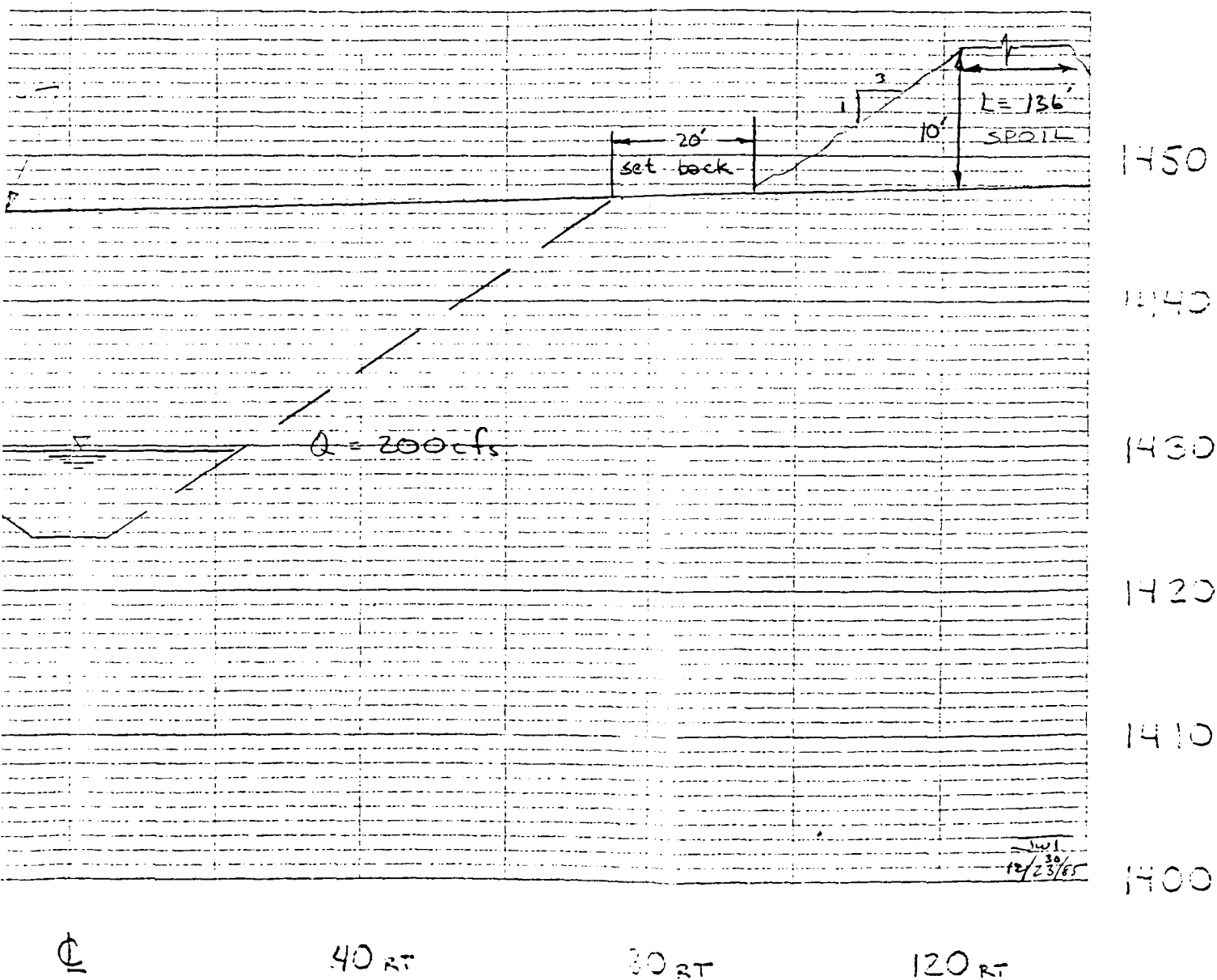
0

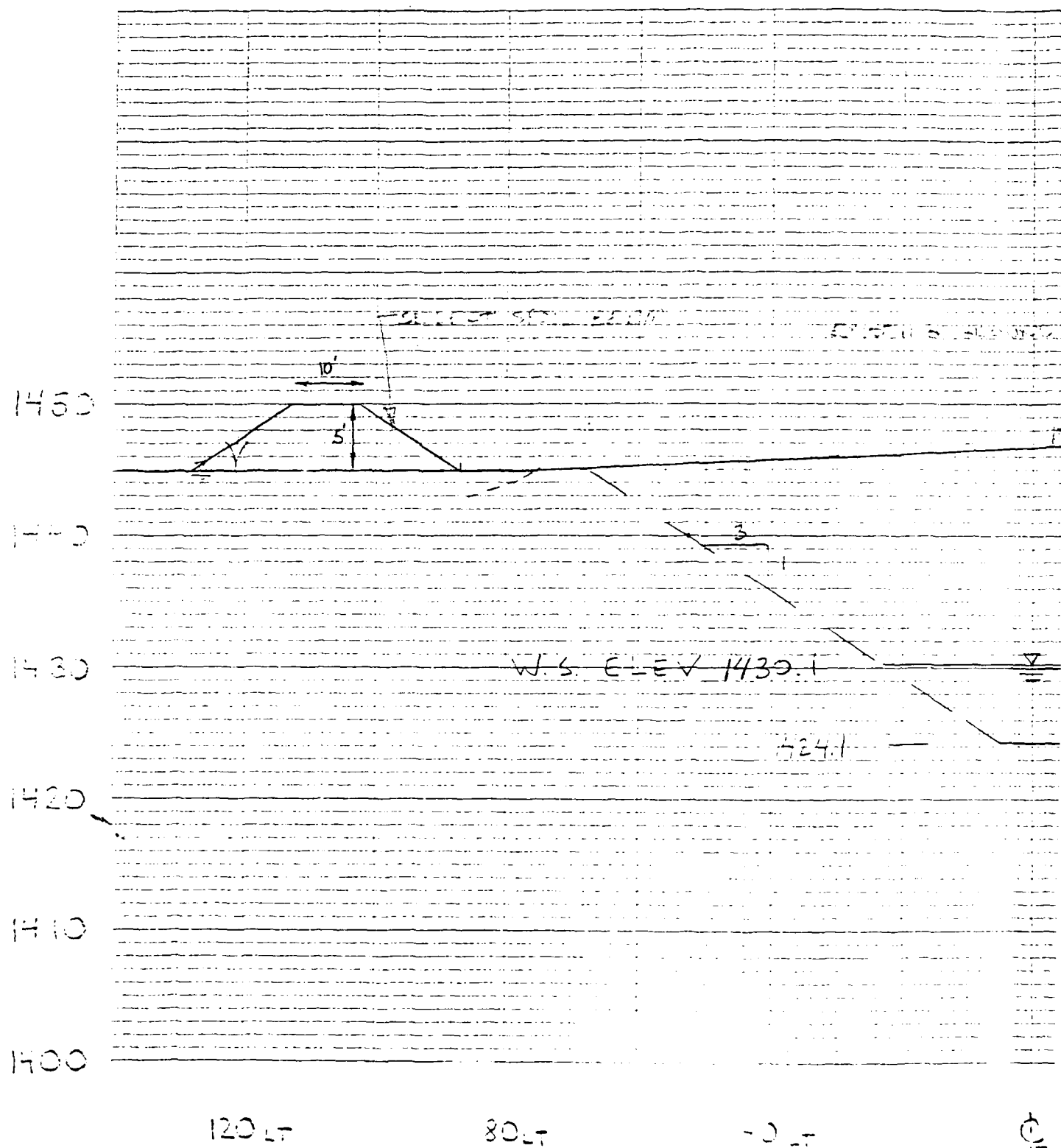


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

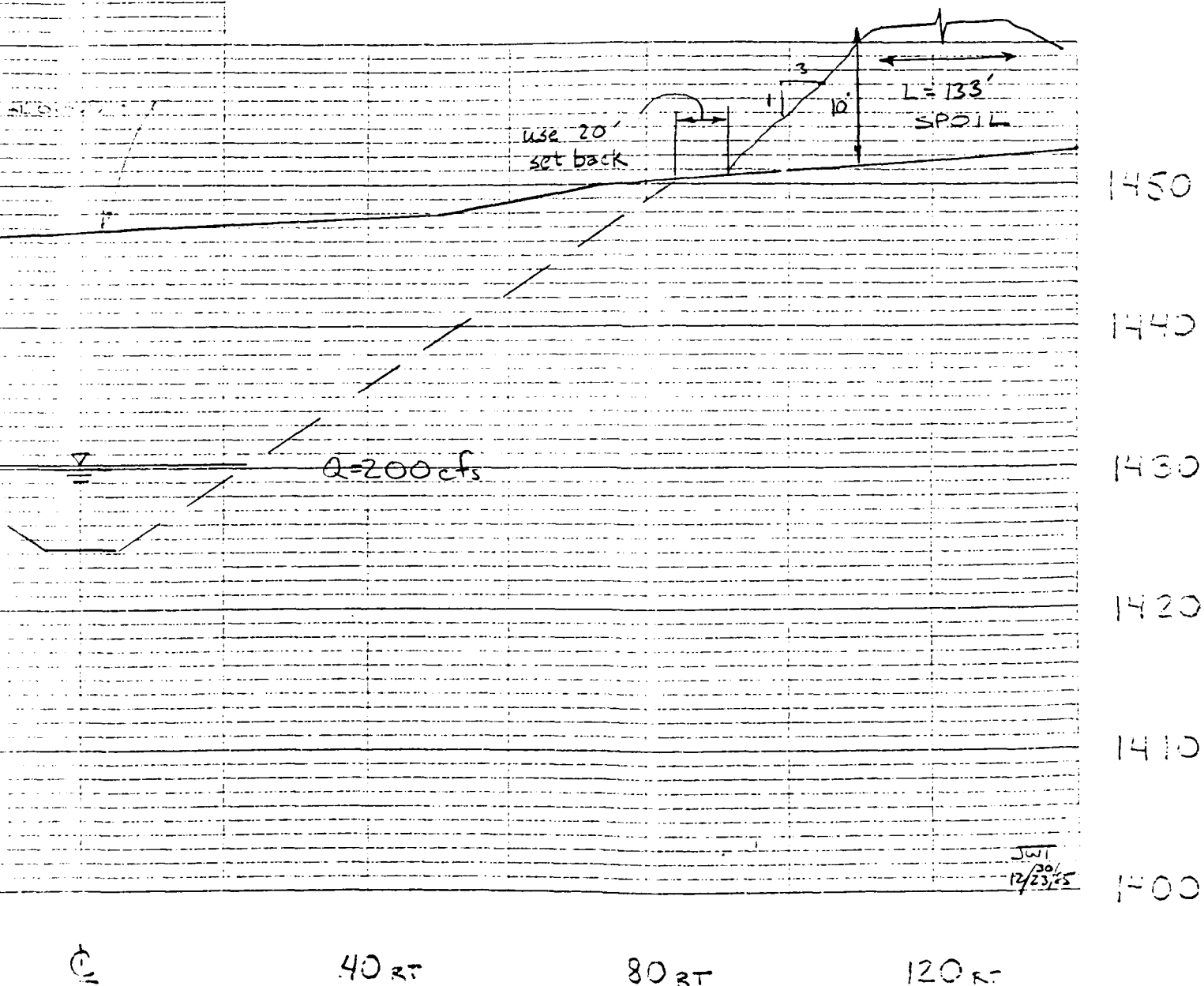
CASE 2G

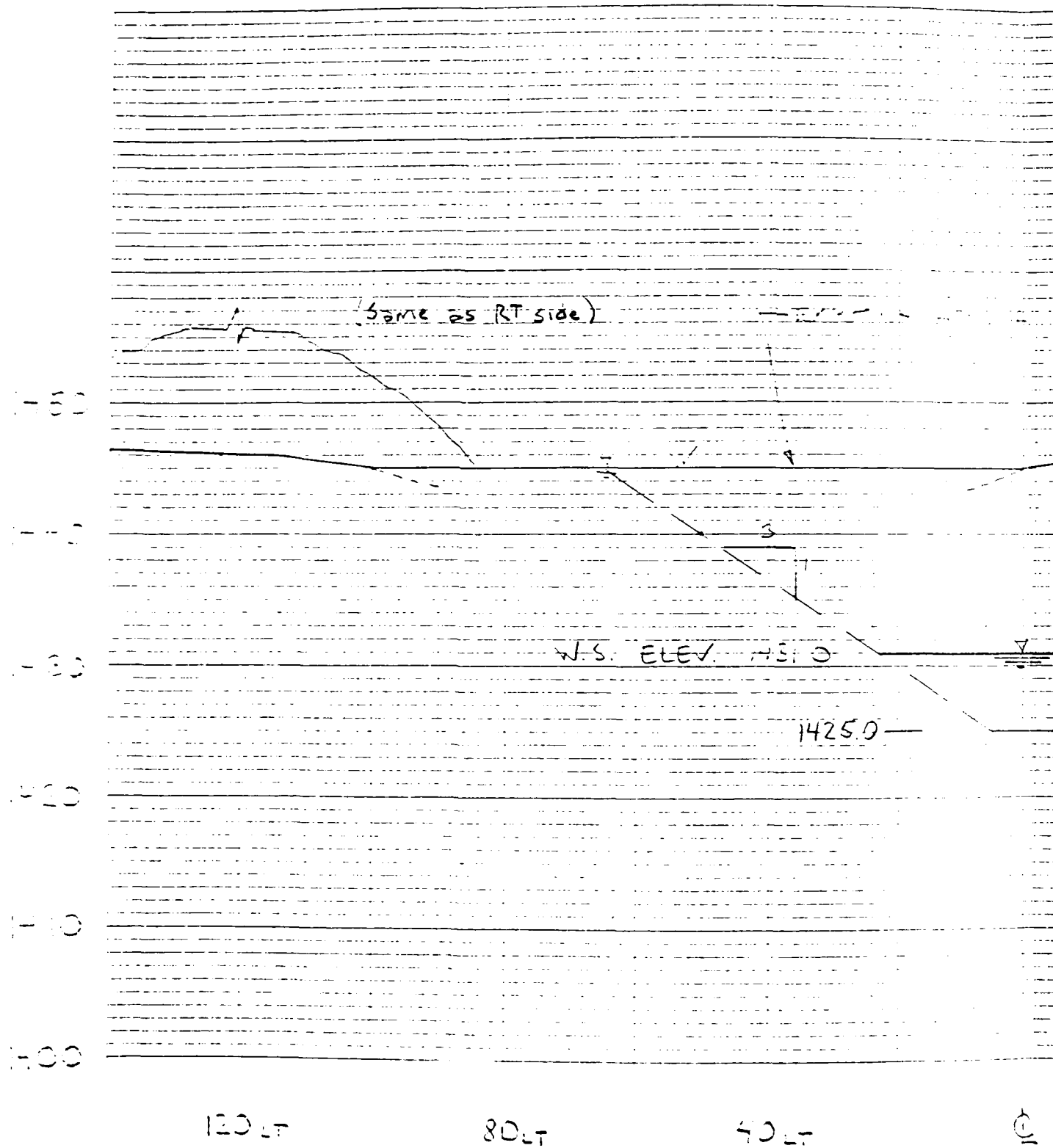
CROSS SECTION STA 244+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 2G CROSS SECTION STA 275+00

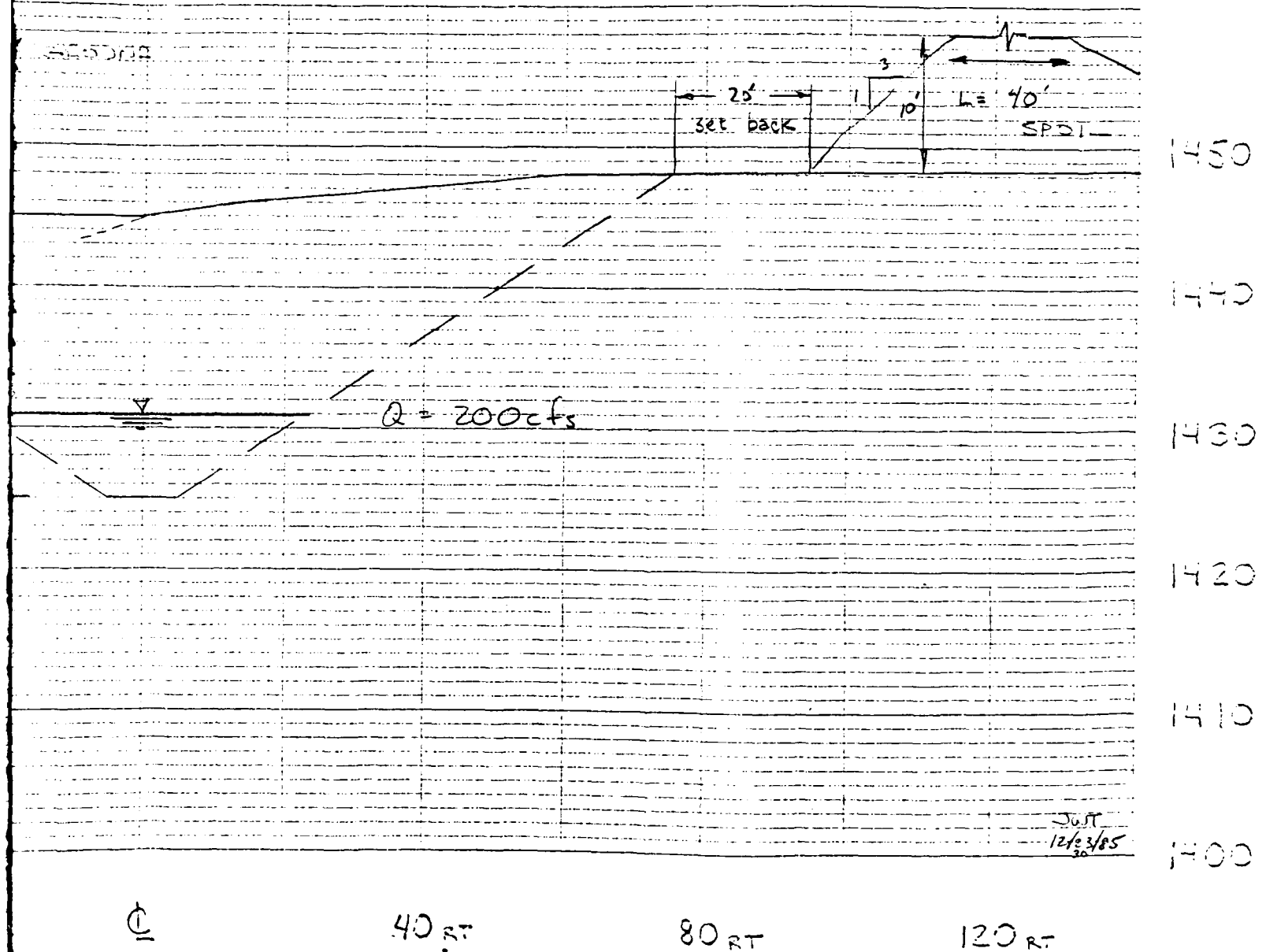




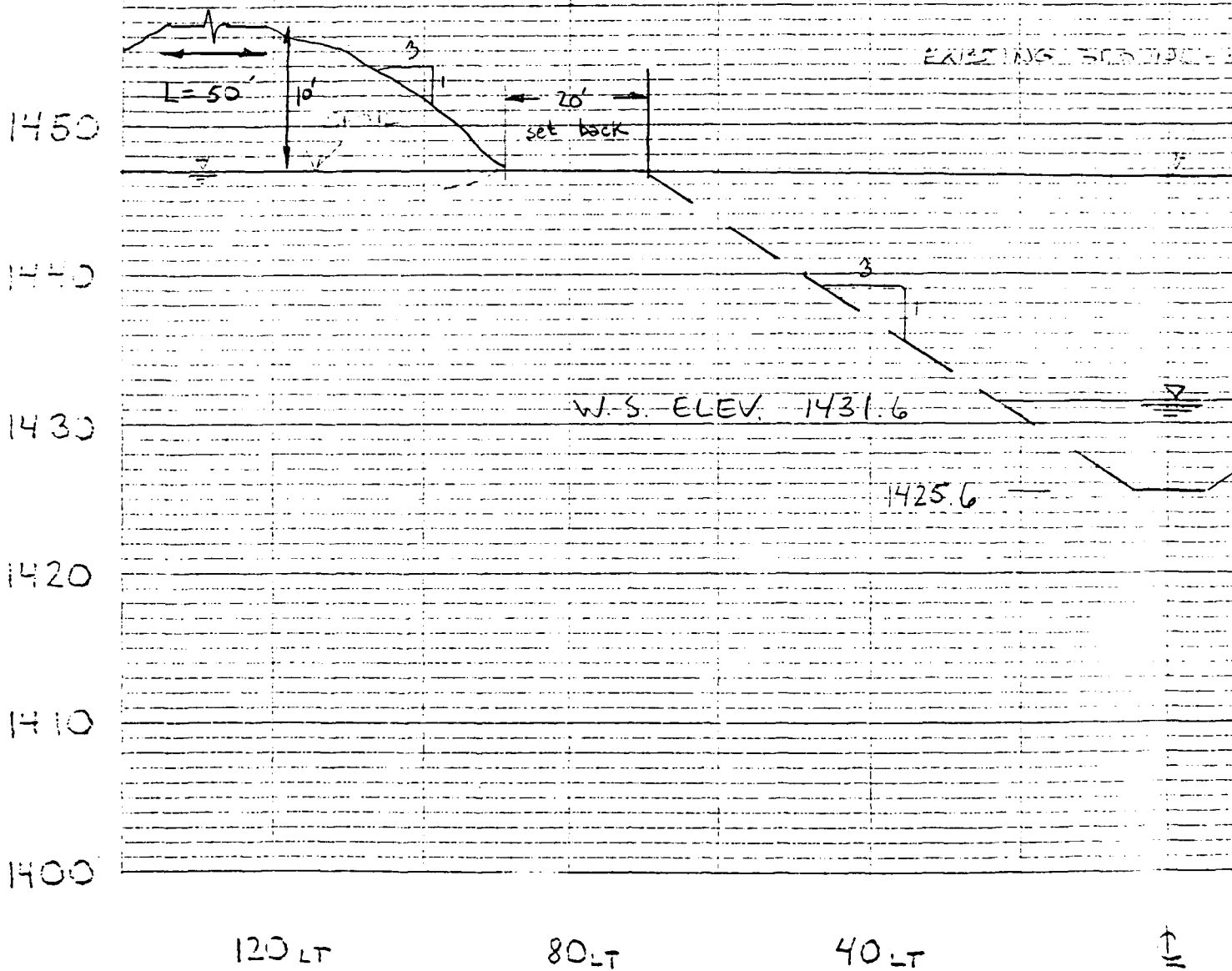
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2G

CROSS SECTION STA 304+00



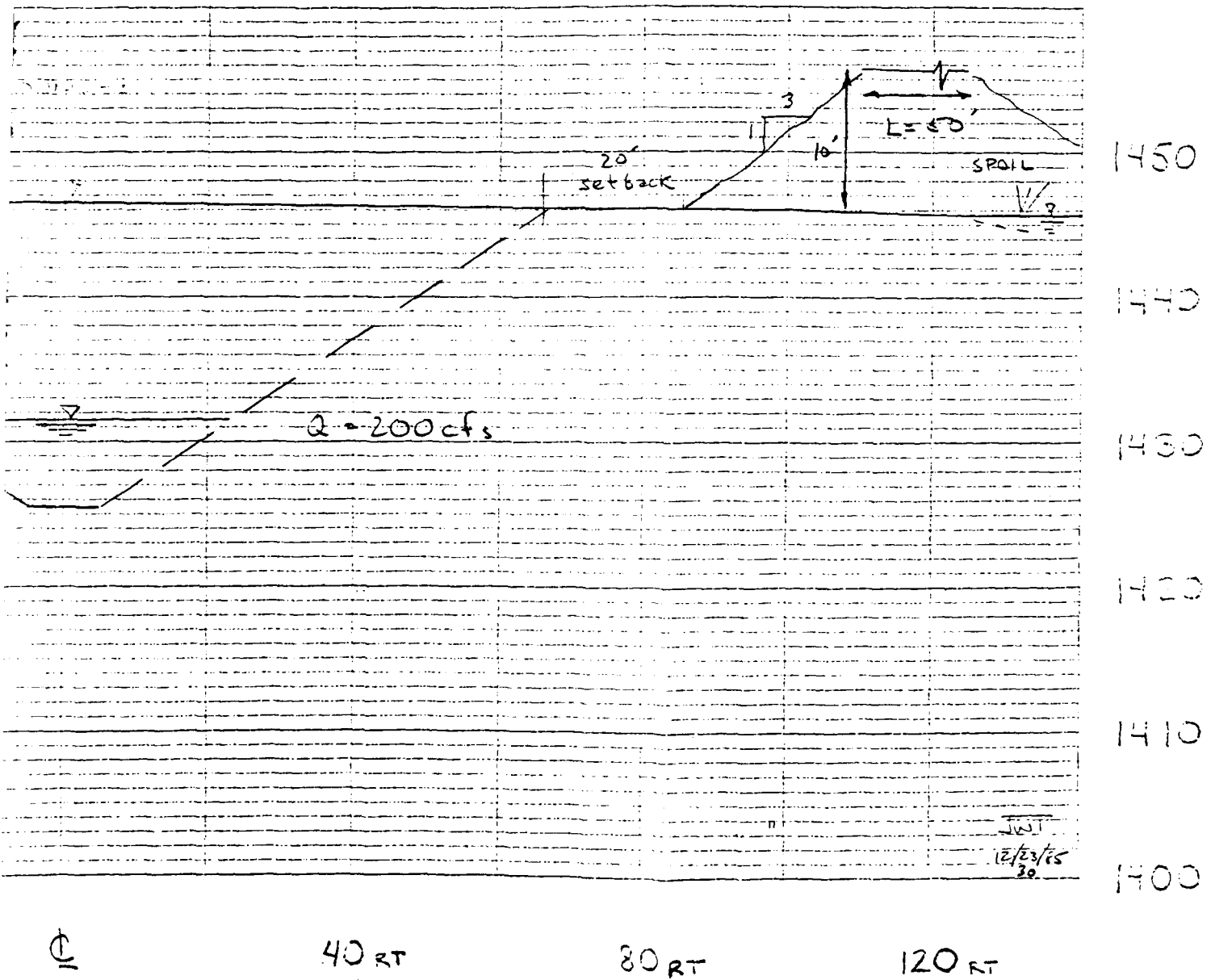


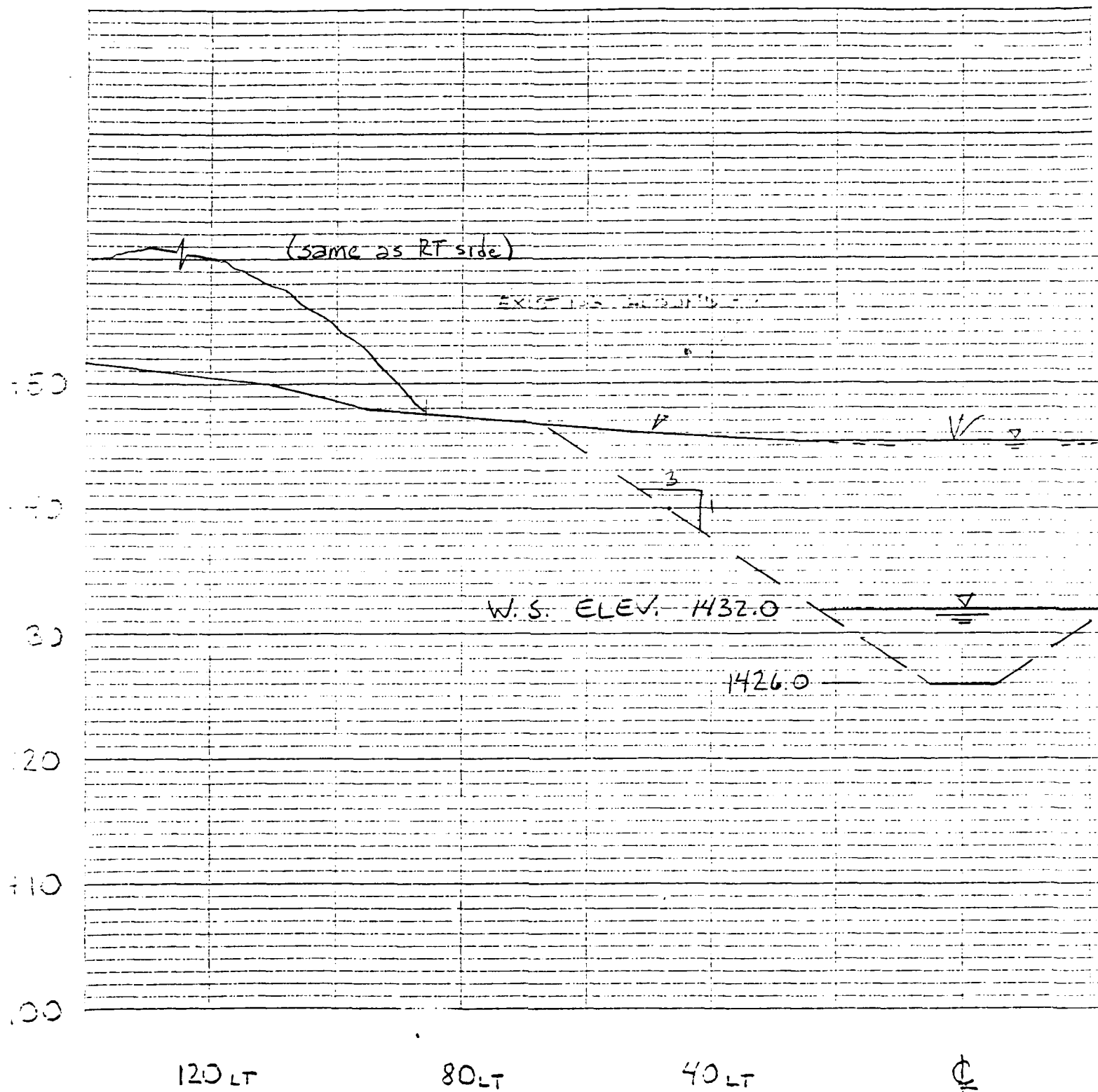


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2G

CROSS SECTION STA 345-00

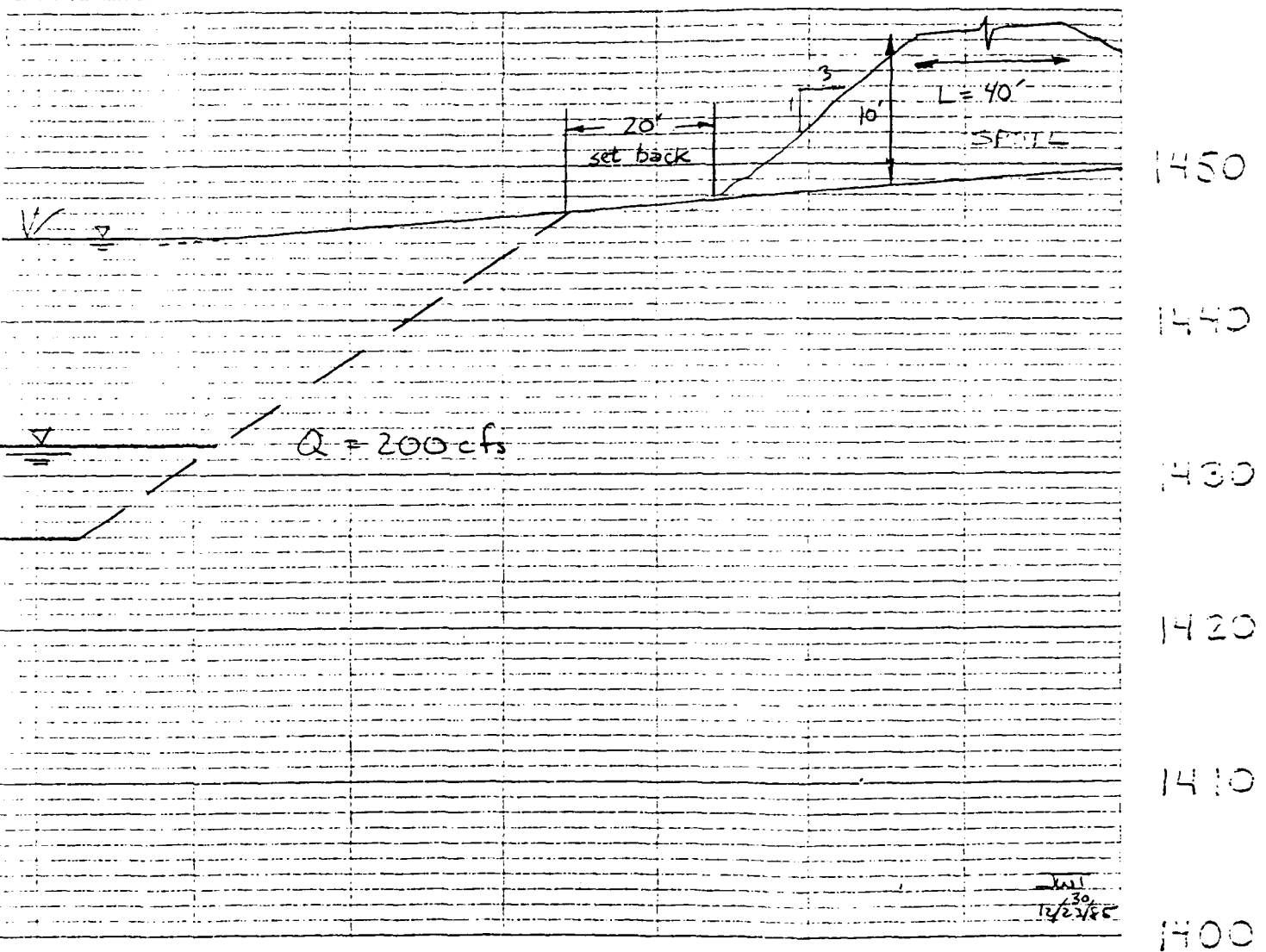




# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE.

CASE 26

CROSS SECTION STA 370+00



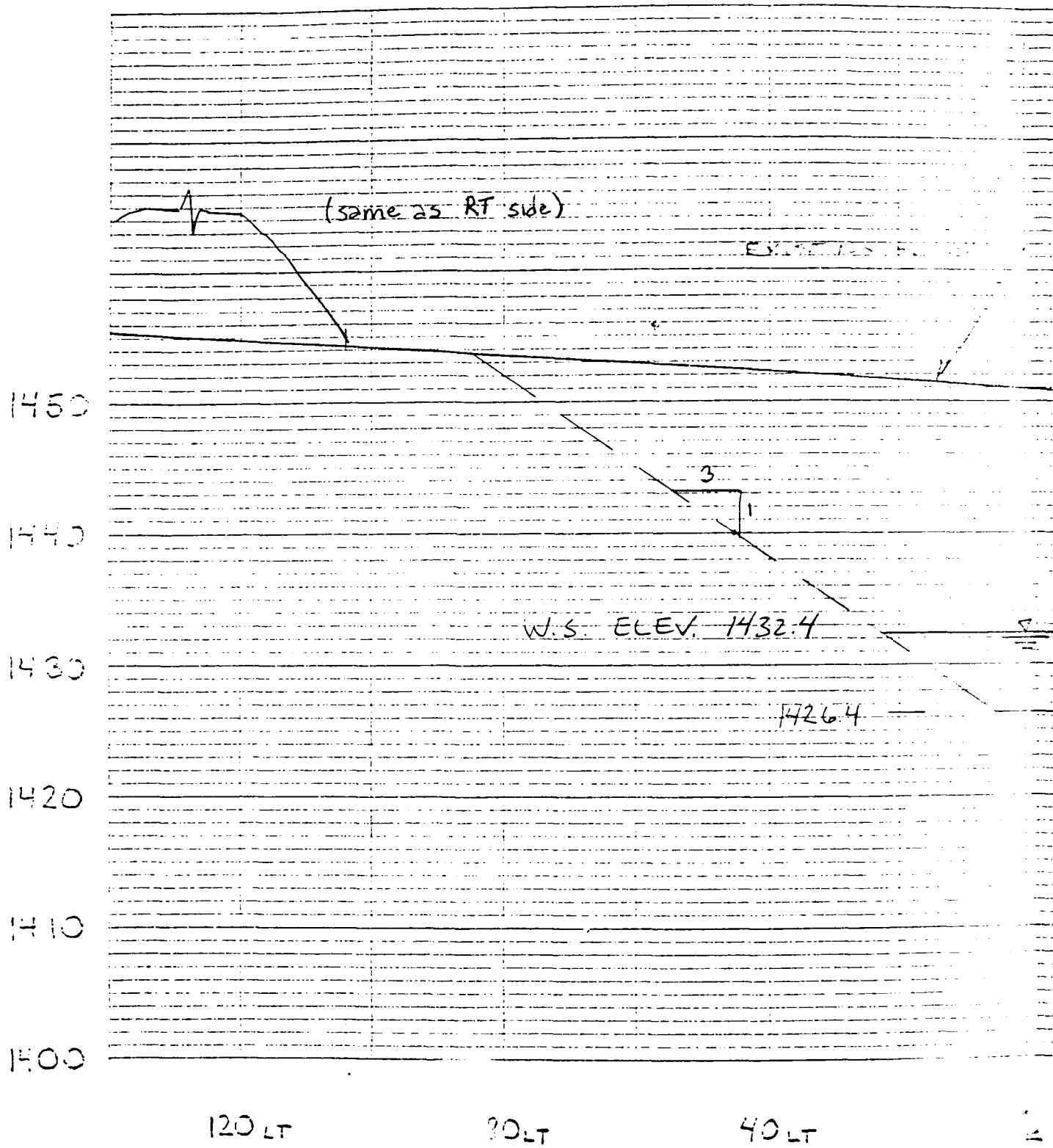
4

40 RT

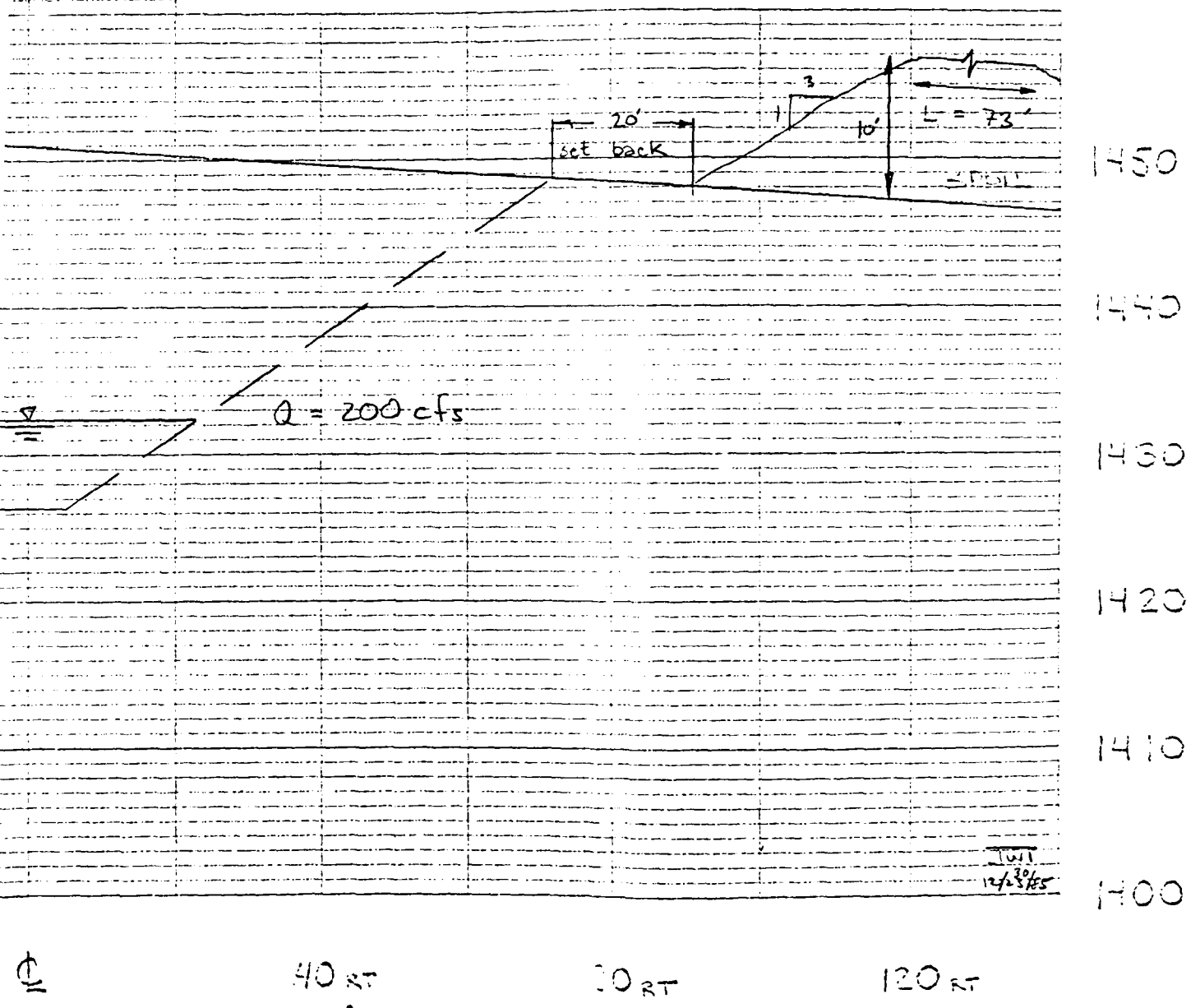
30 RT

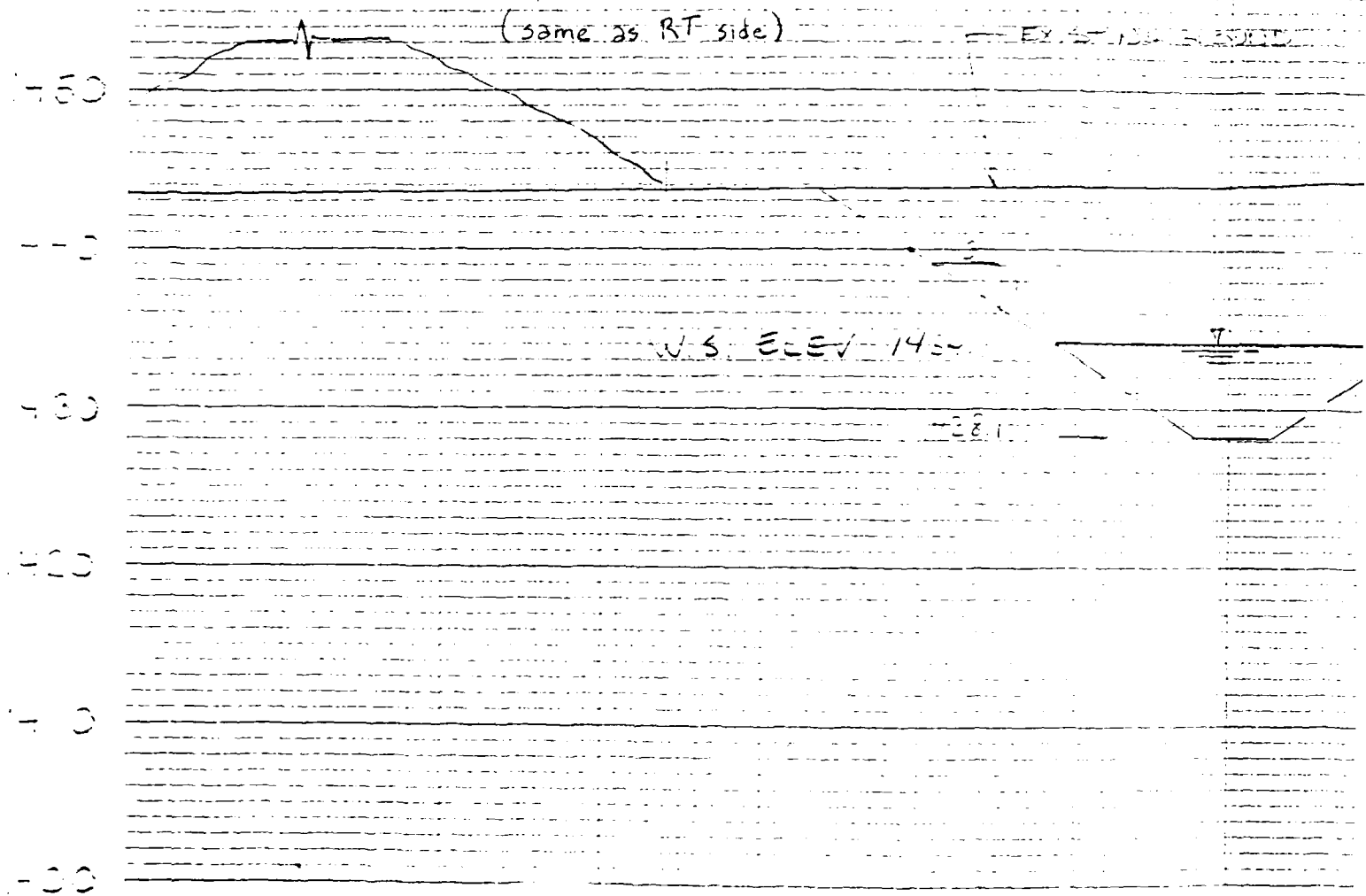
120 RT

2 1/2" C-



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 2G  
CROSS SECTION STA 398+00

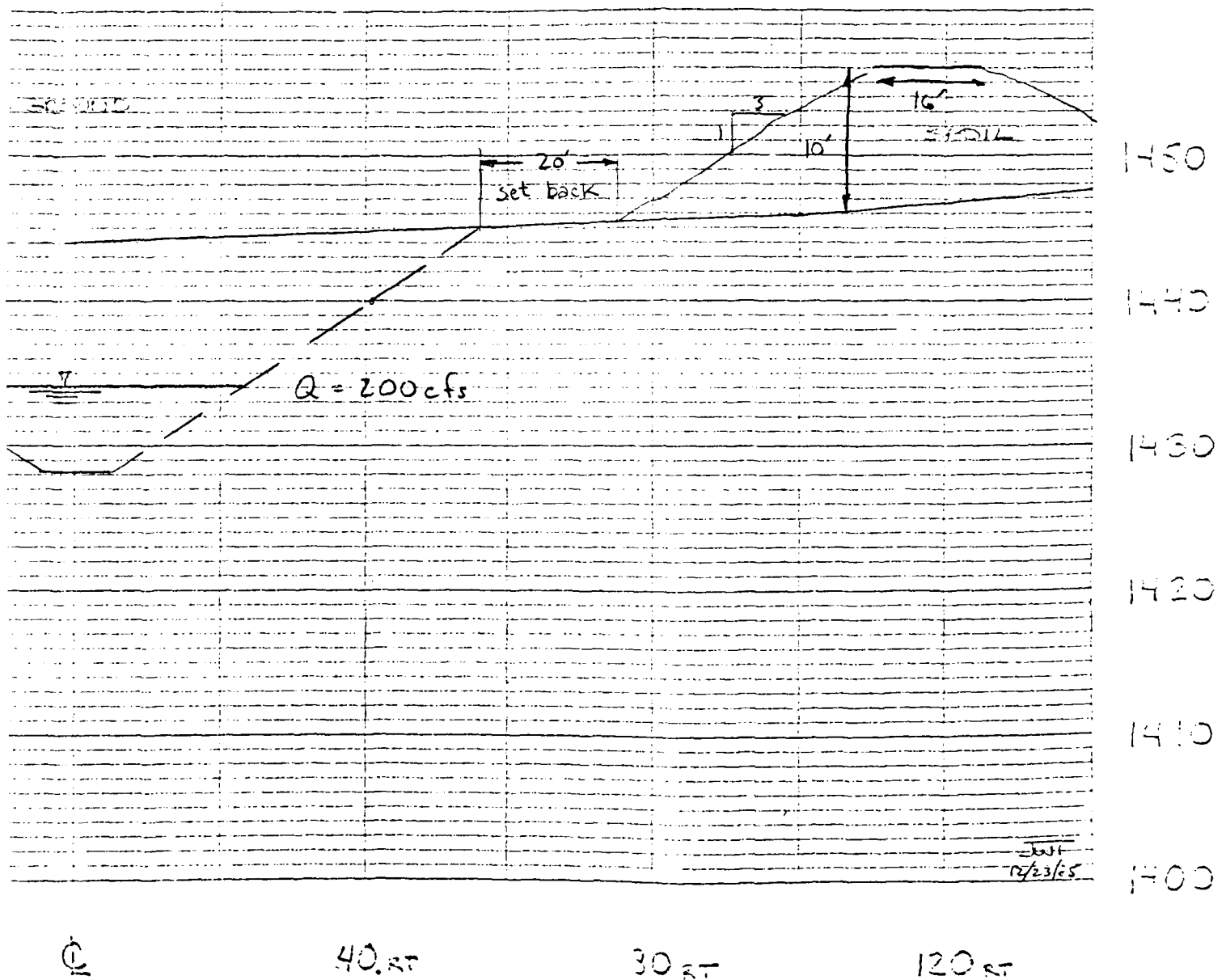




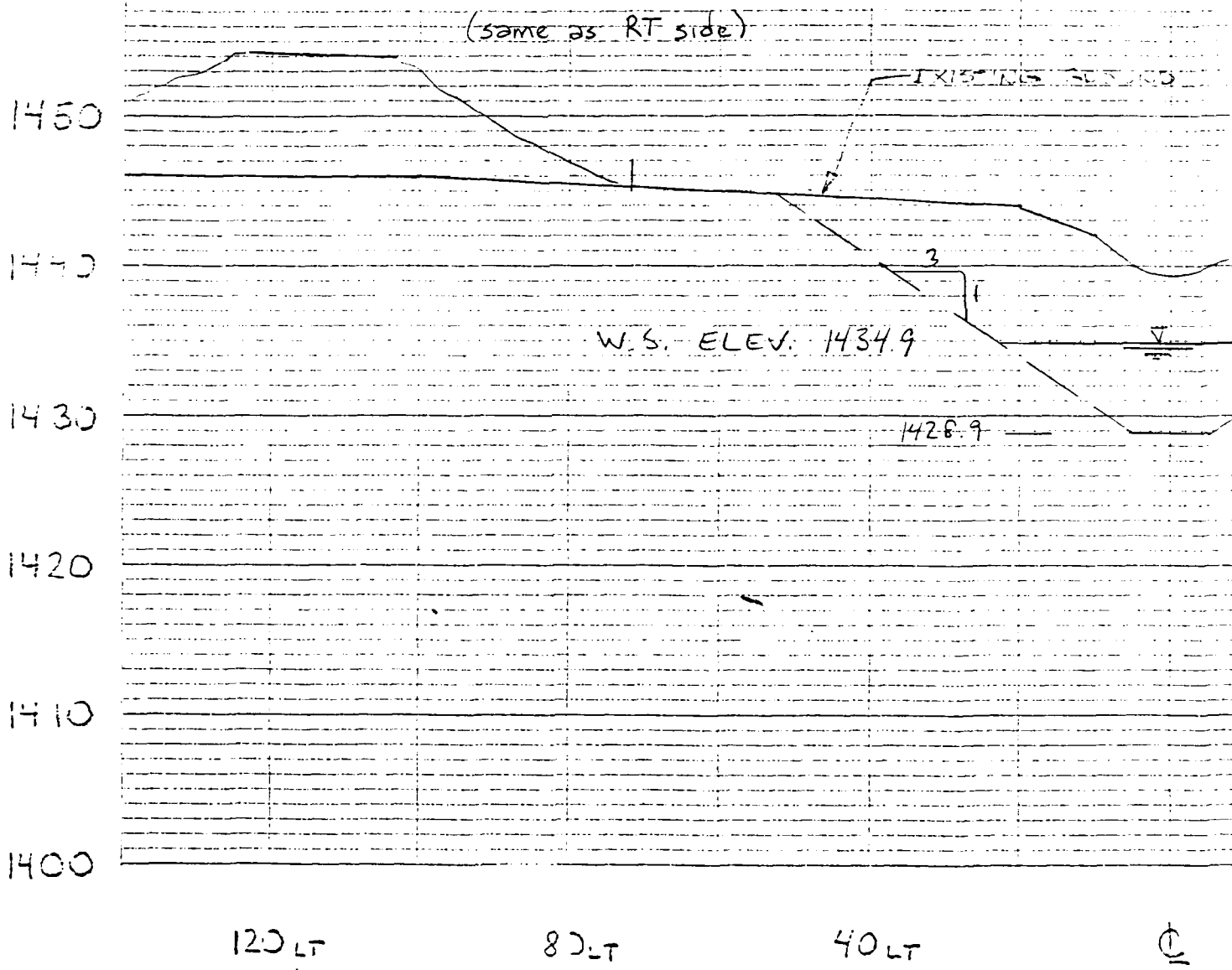
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2G

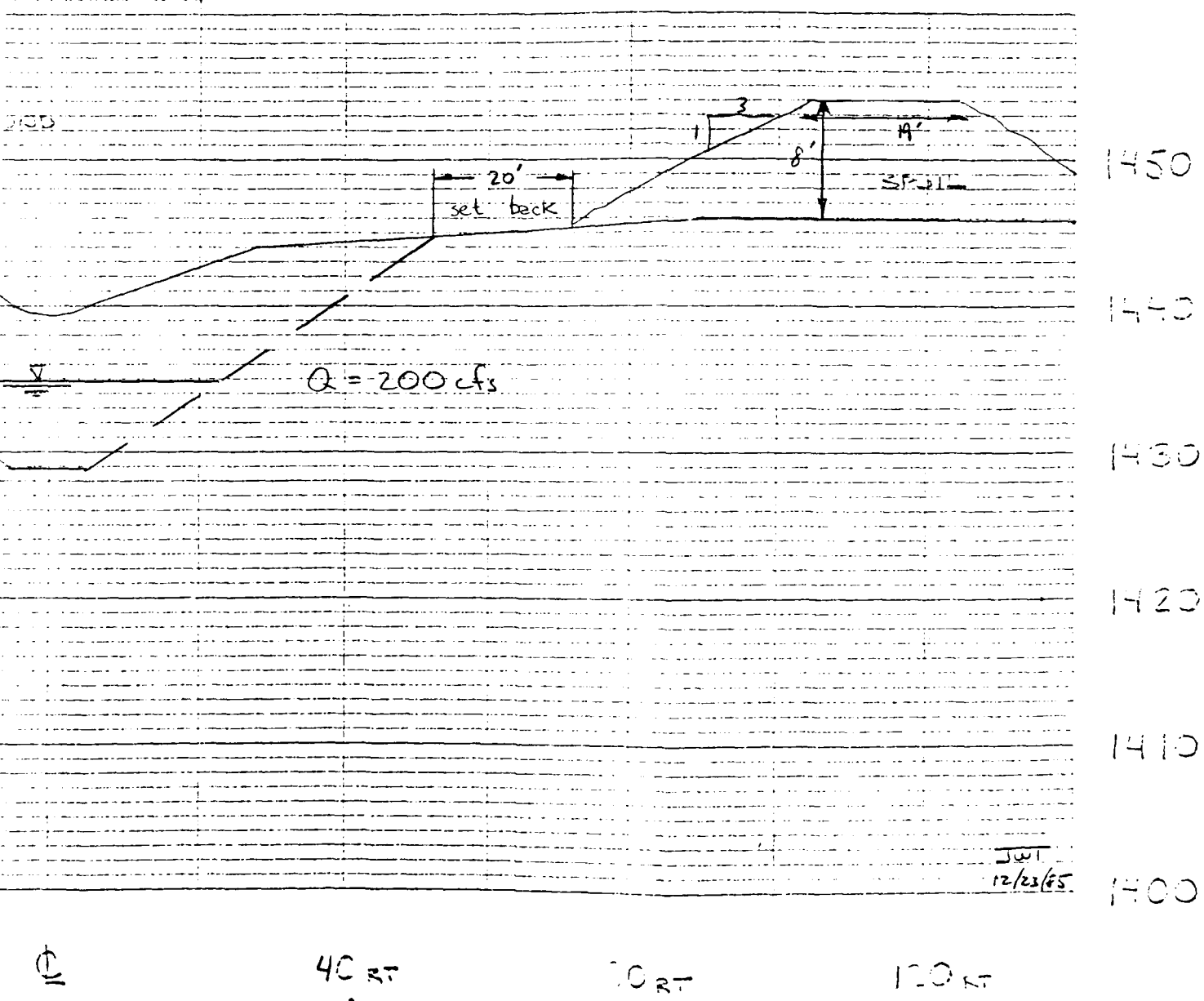
CROSS SECTION STA 485+00







# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 2G CROSS SECTION STA 514+00



1450

1440

1430

1420

1410

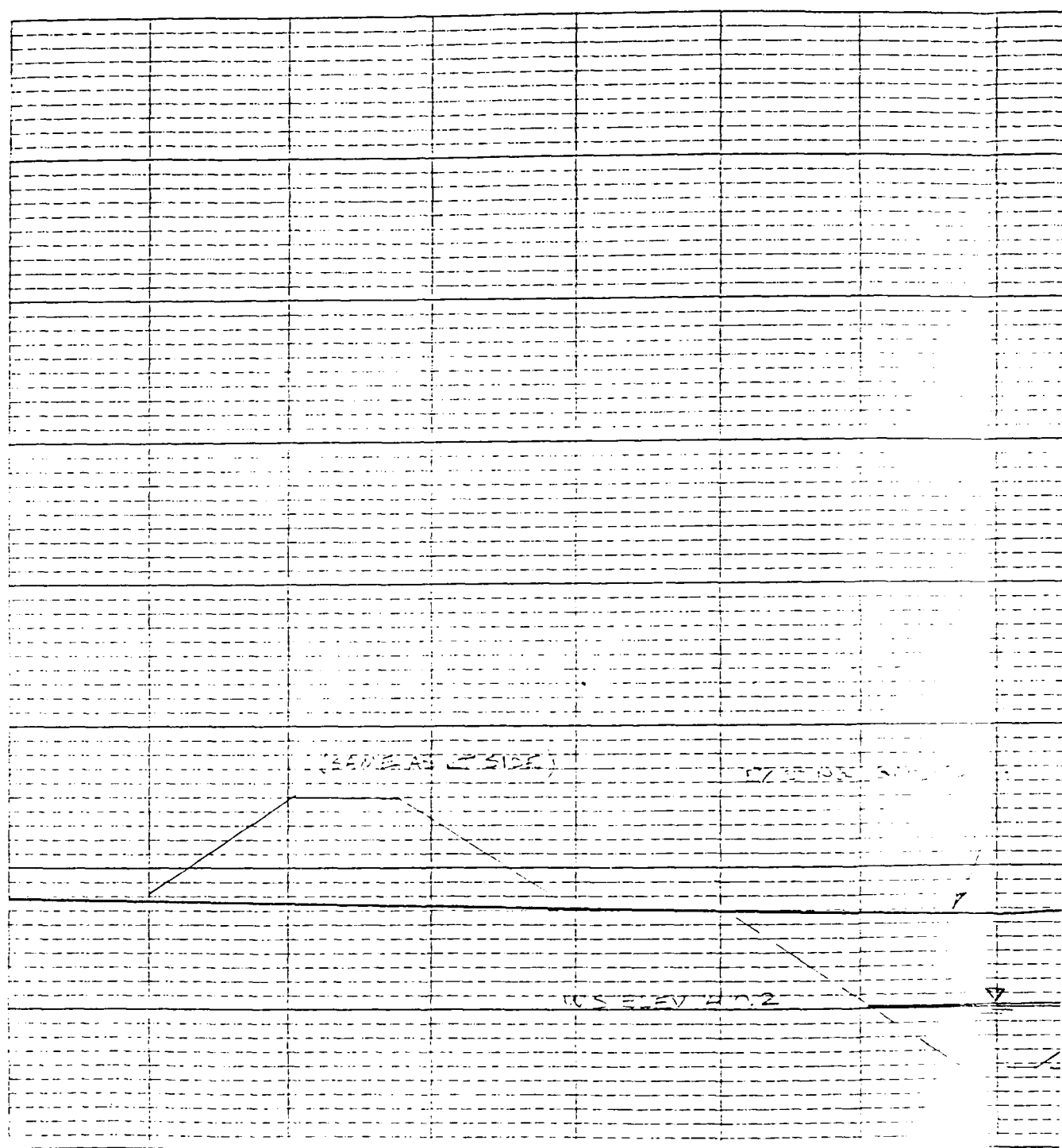
1400

120<sub>LT</sub>

80<sub>LT</sub>

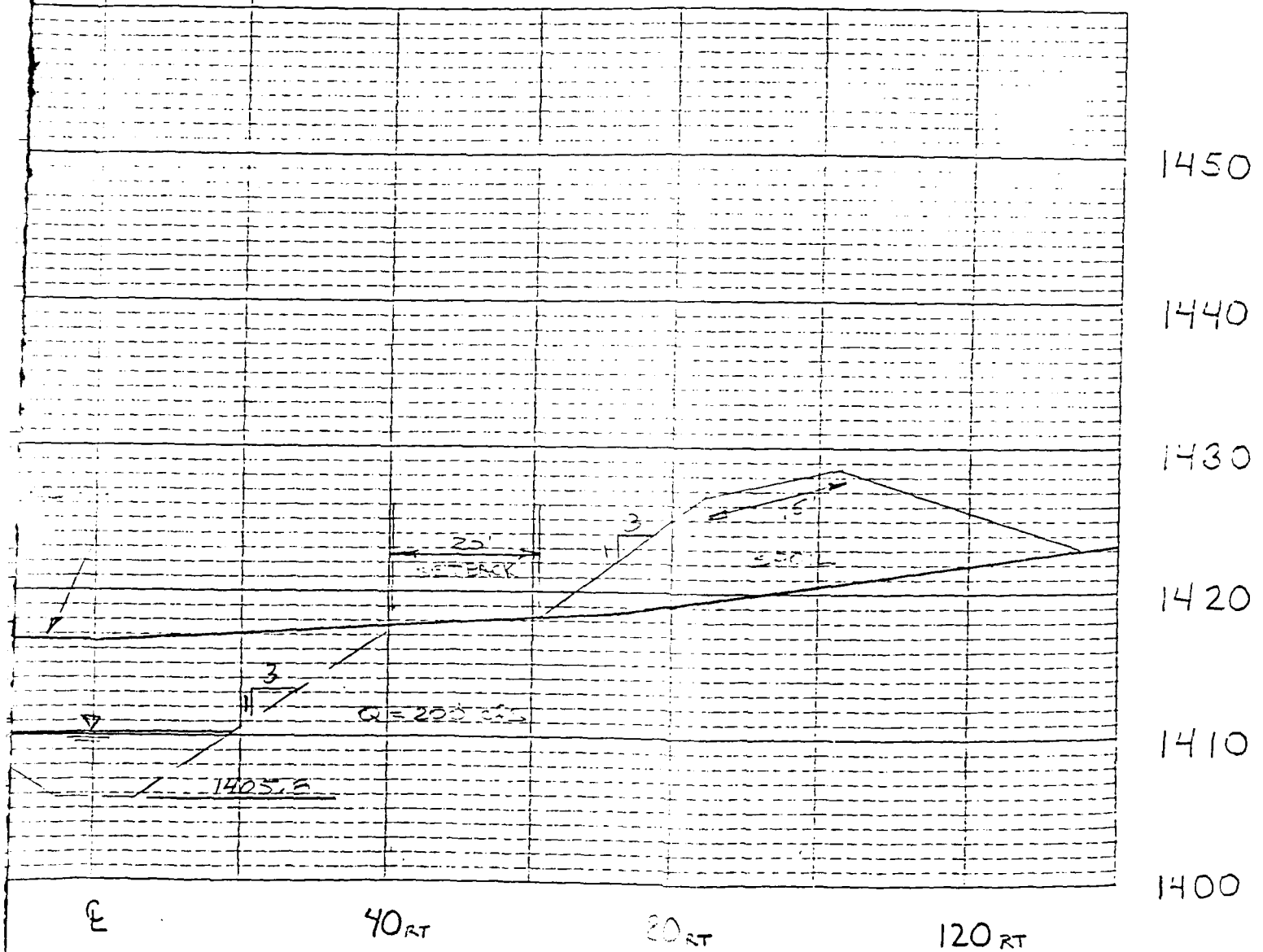
40<sub>LT</sub>

E



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE 2P  
CROSS SECTION STA 25+00



1450

(same as RT side)

1440

1430

1420

1410

1400

120<sub>LT</sub>

80<sub>LT</sub>

40<sub>LT</sub>

℄

W.S. ELEV = 1425.9

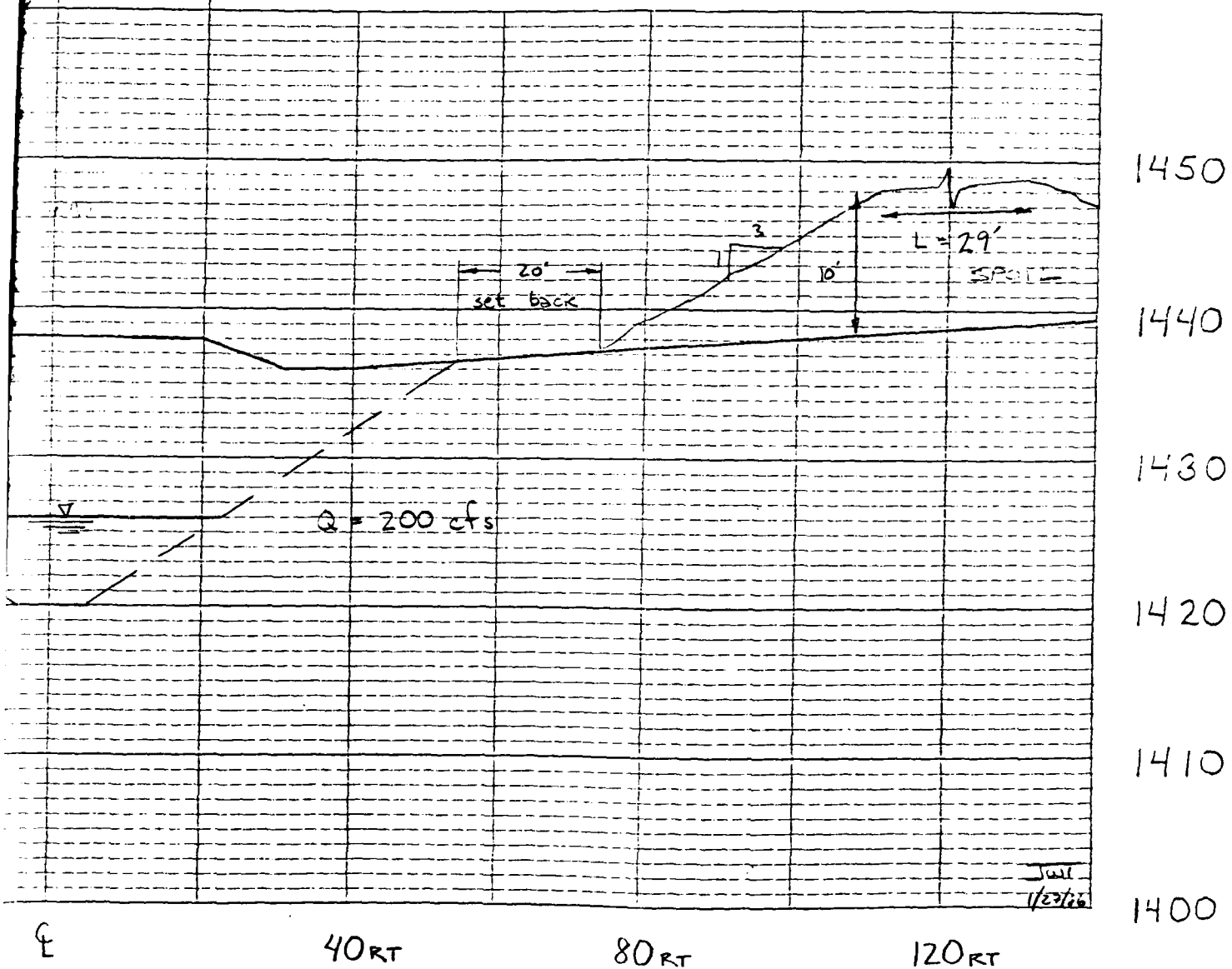
1420.0

3

1

EXT. LOS 5.25%

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 2P  
CROSS SECTION STA 70+00



1450

1440

1430

1420

1410

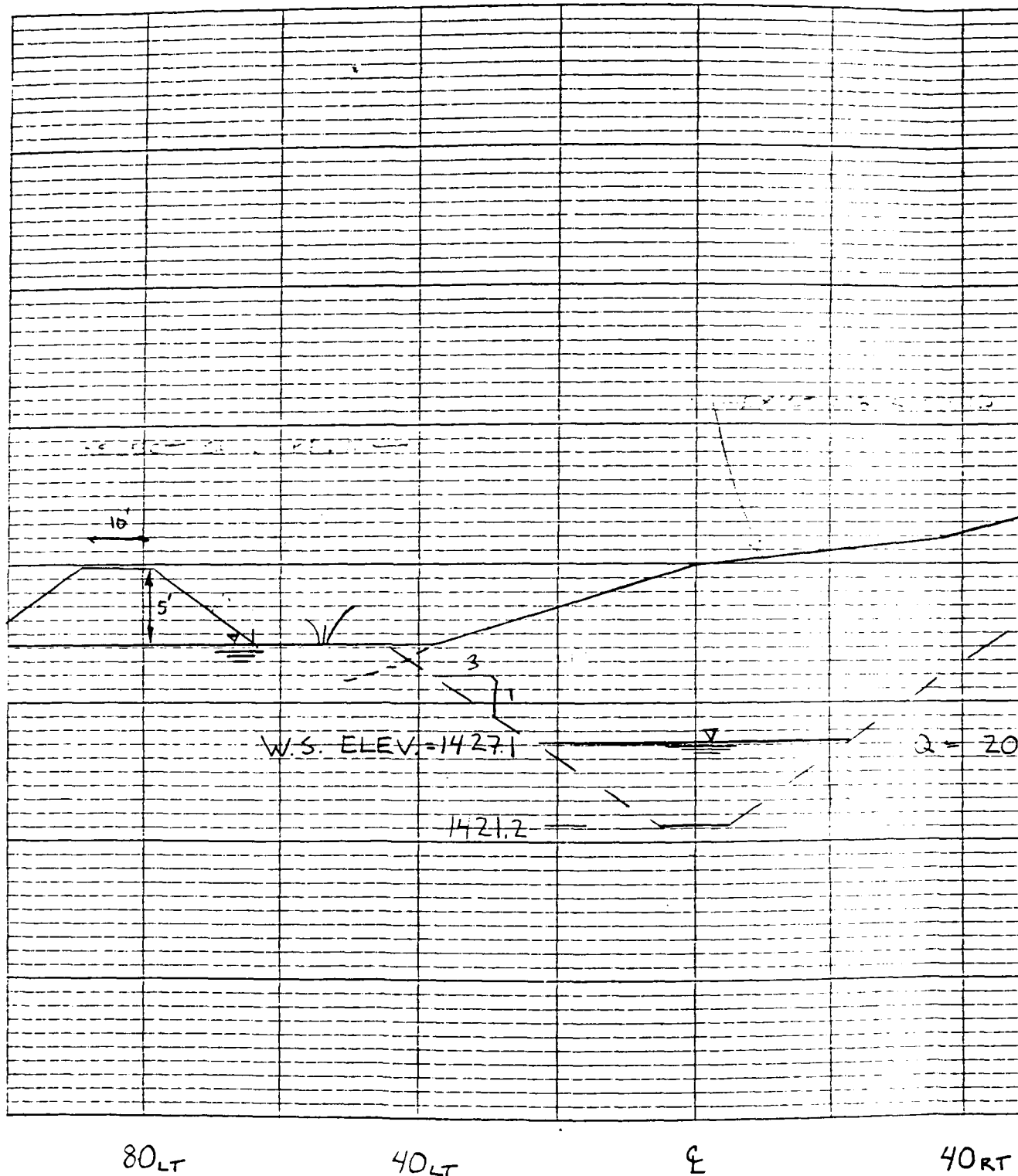
1400

80<sub>LT</sub>

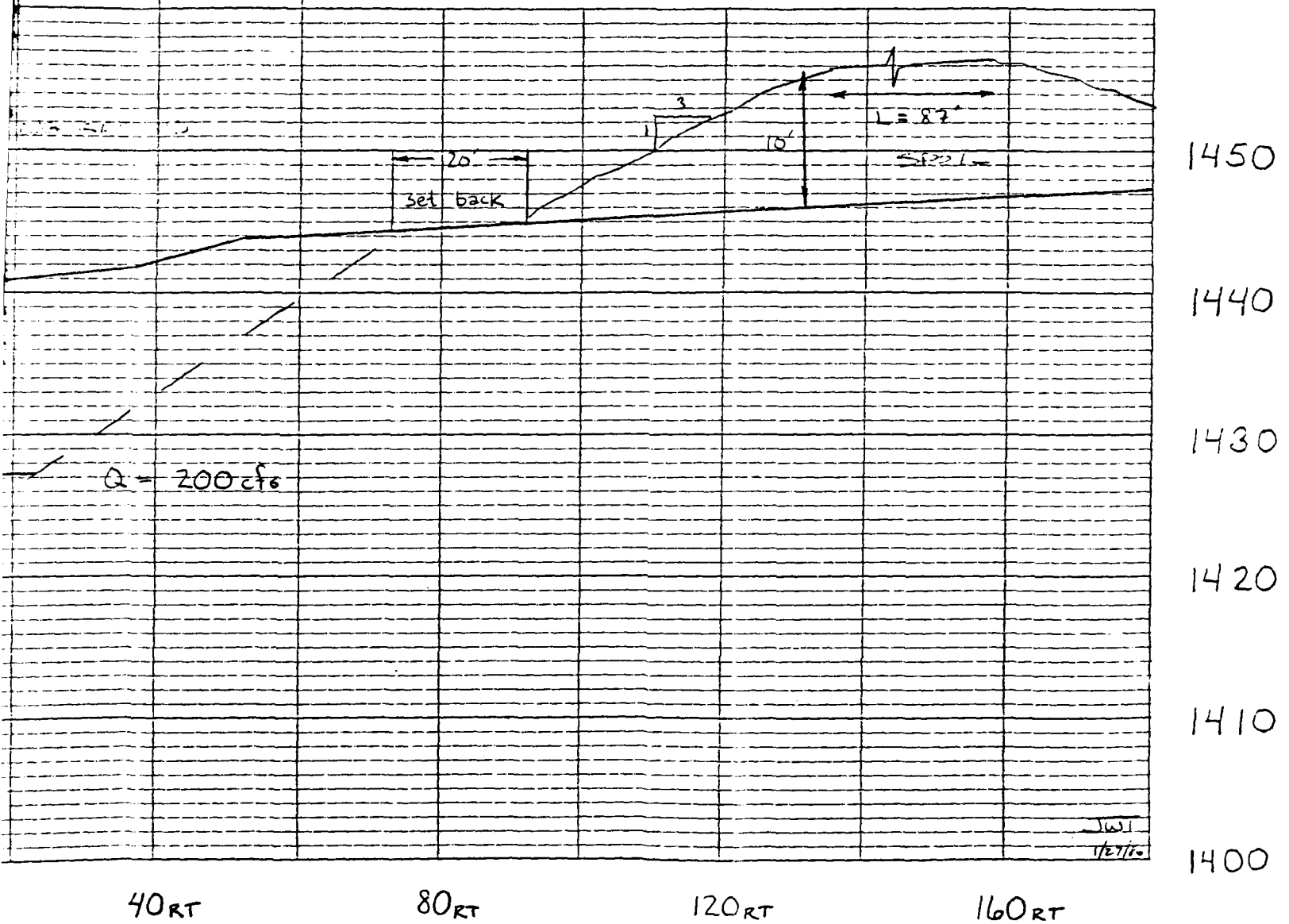
40<sub>LT</sub>

℄

40<sub>RT</sub>



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 2P  
CROSS SECTION STA 120+00





1450

(same as RT side)

1440

1430

W.S. ELEV. 1428.0

1420

1422.1

1410

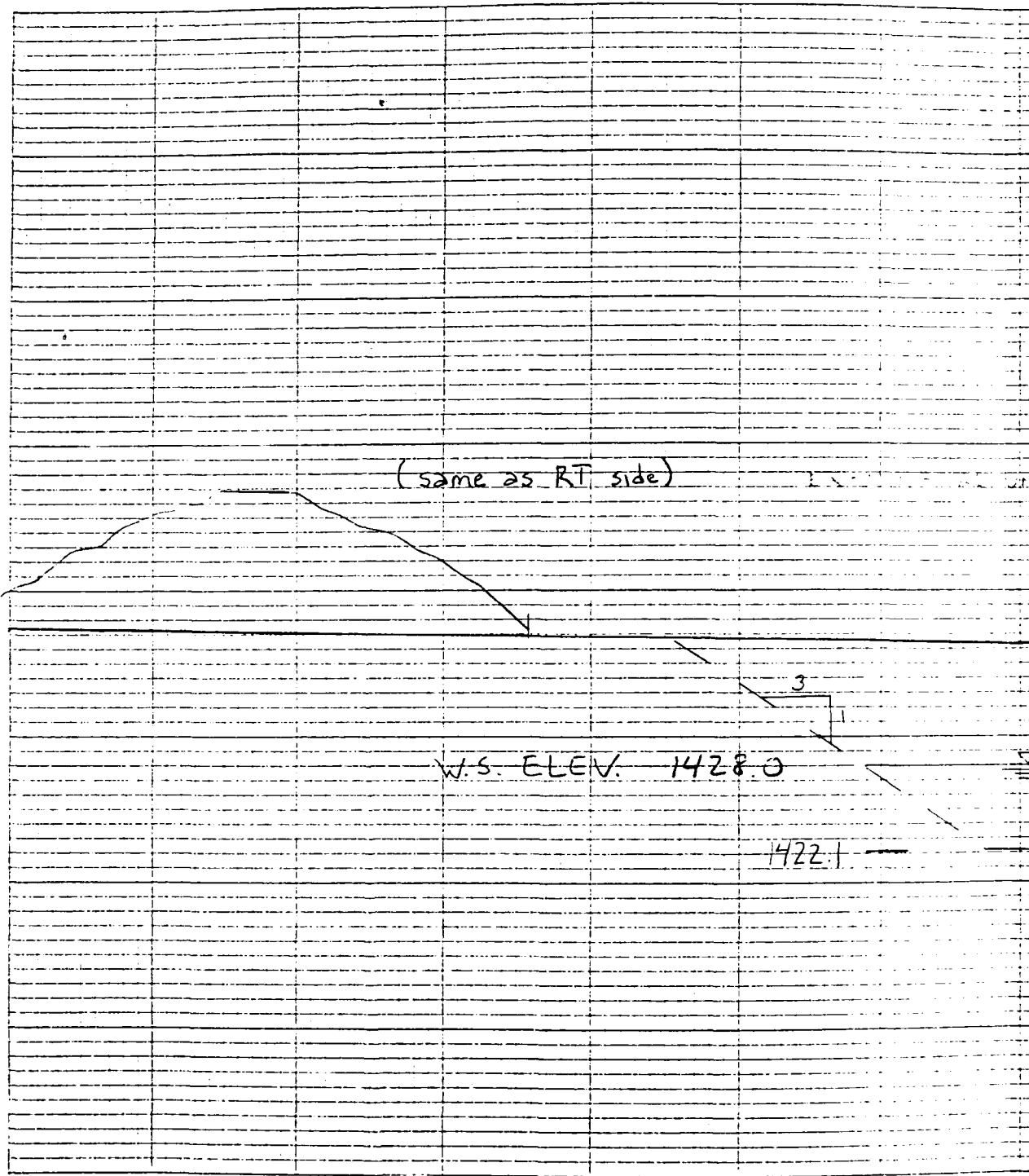
1400

120 LT

30 LT

40 LT

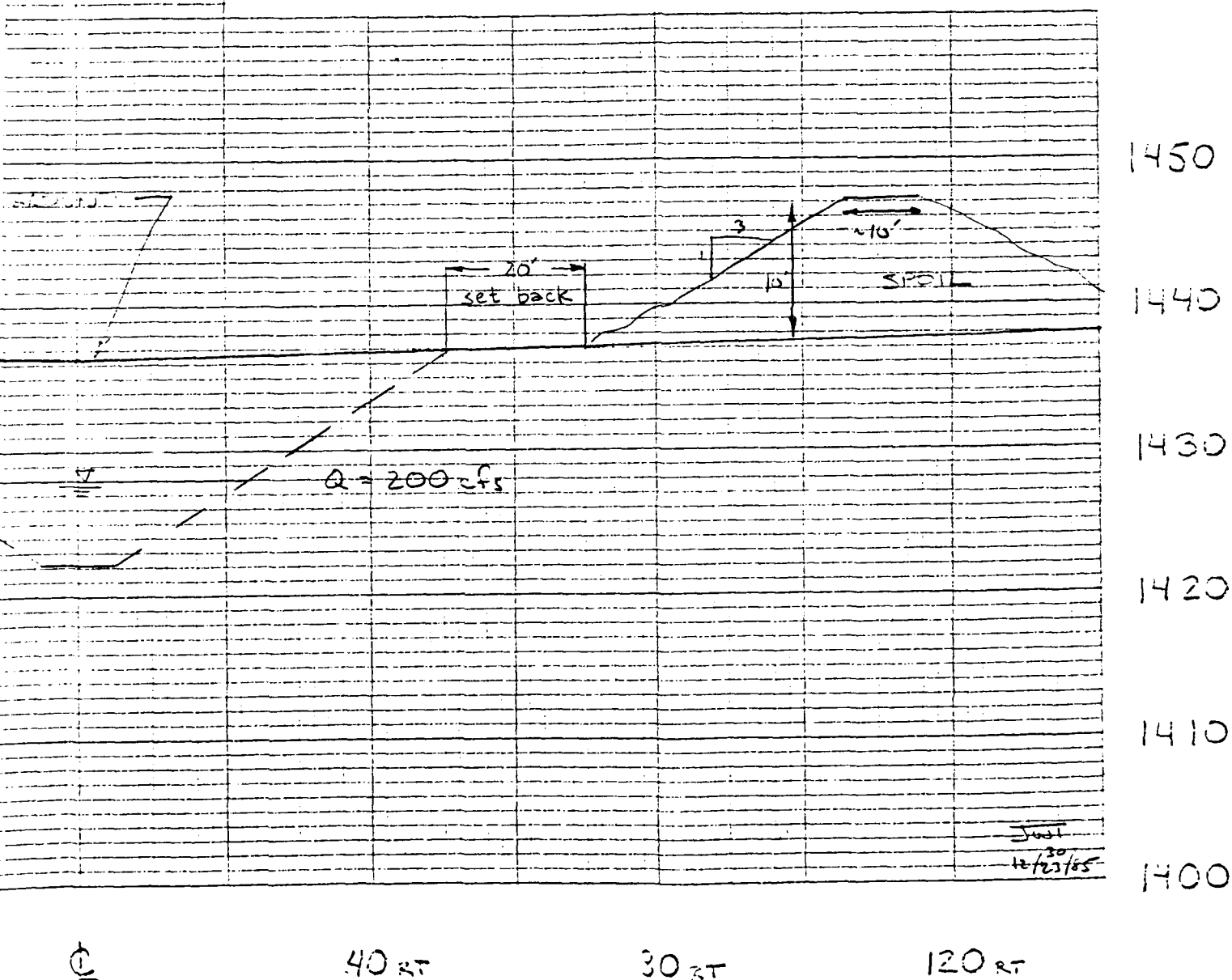
0



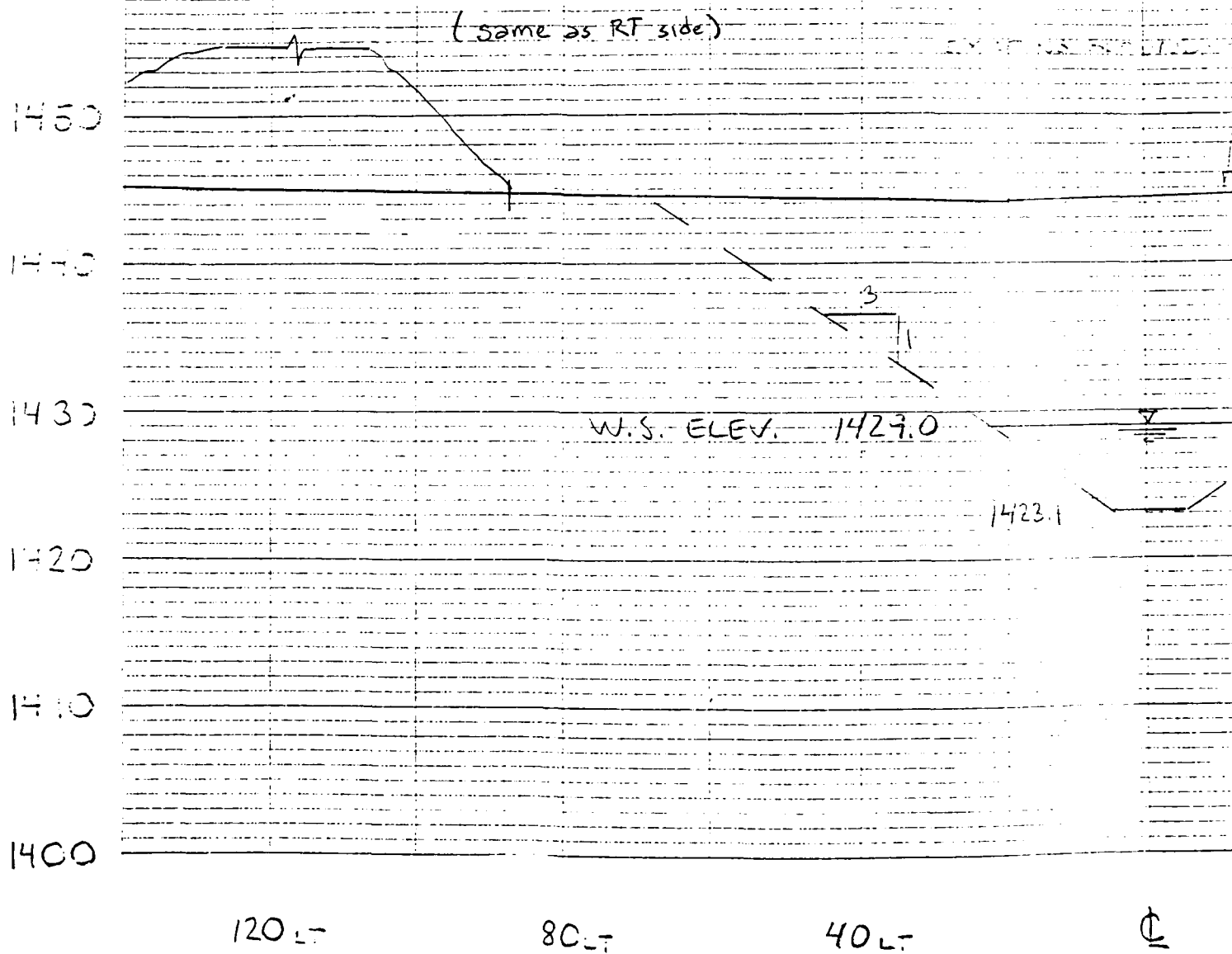
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2P

CROSS SECTION STA 170+00



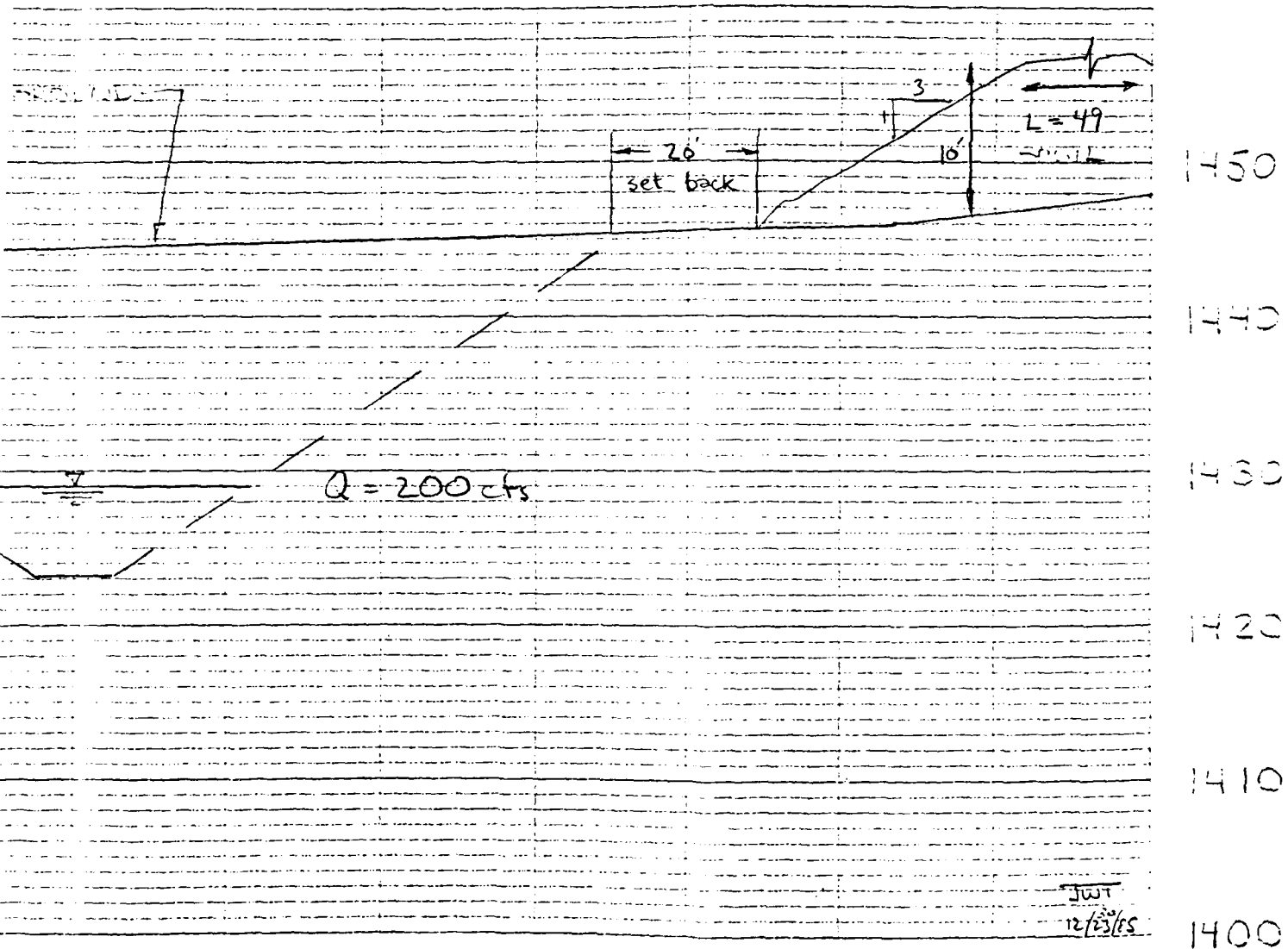
2

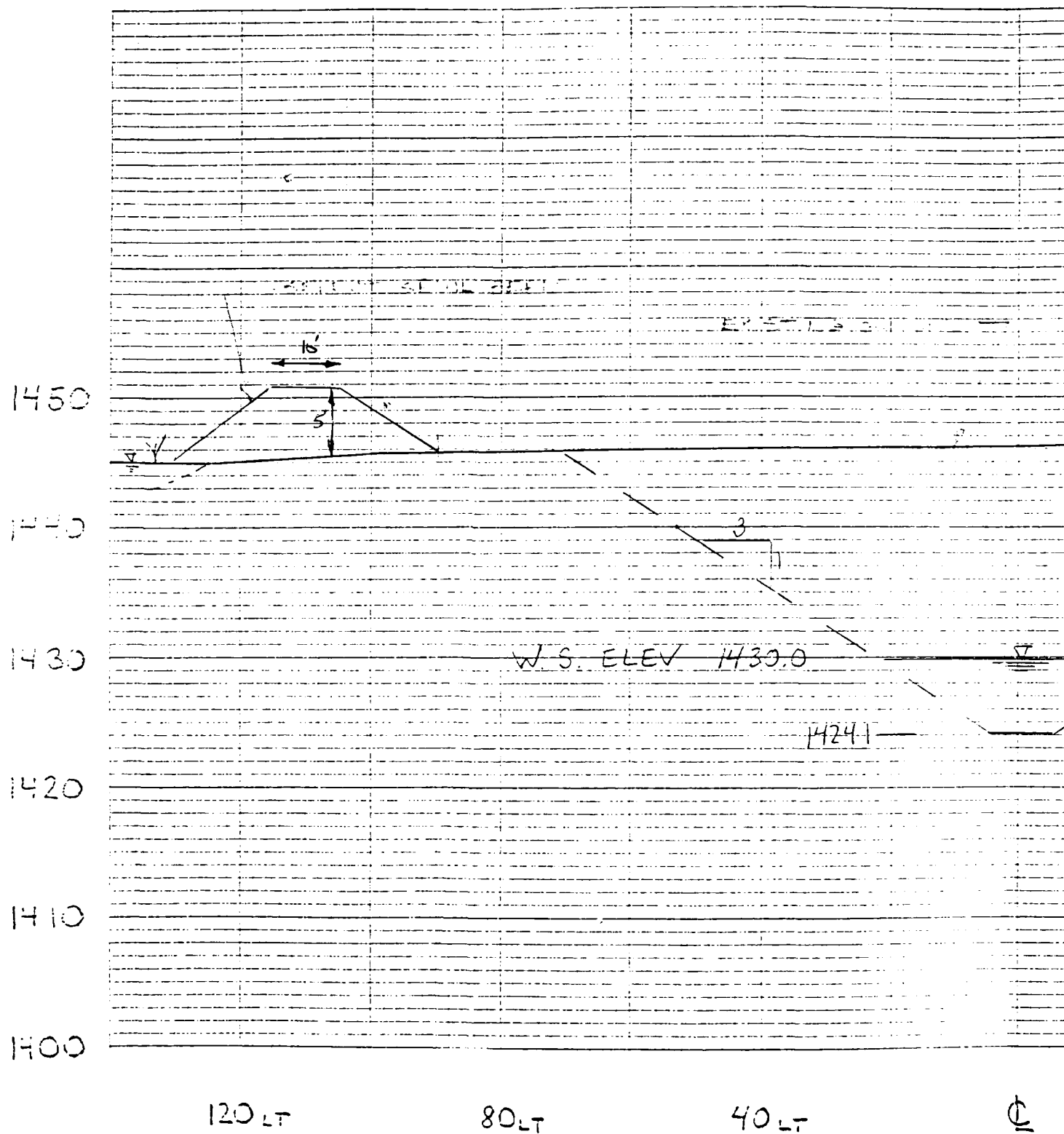


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

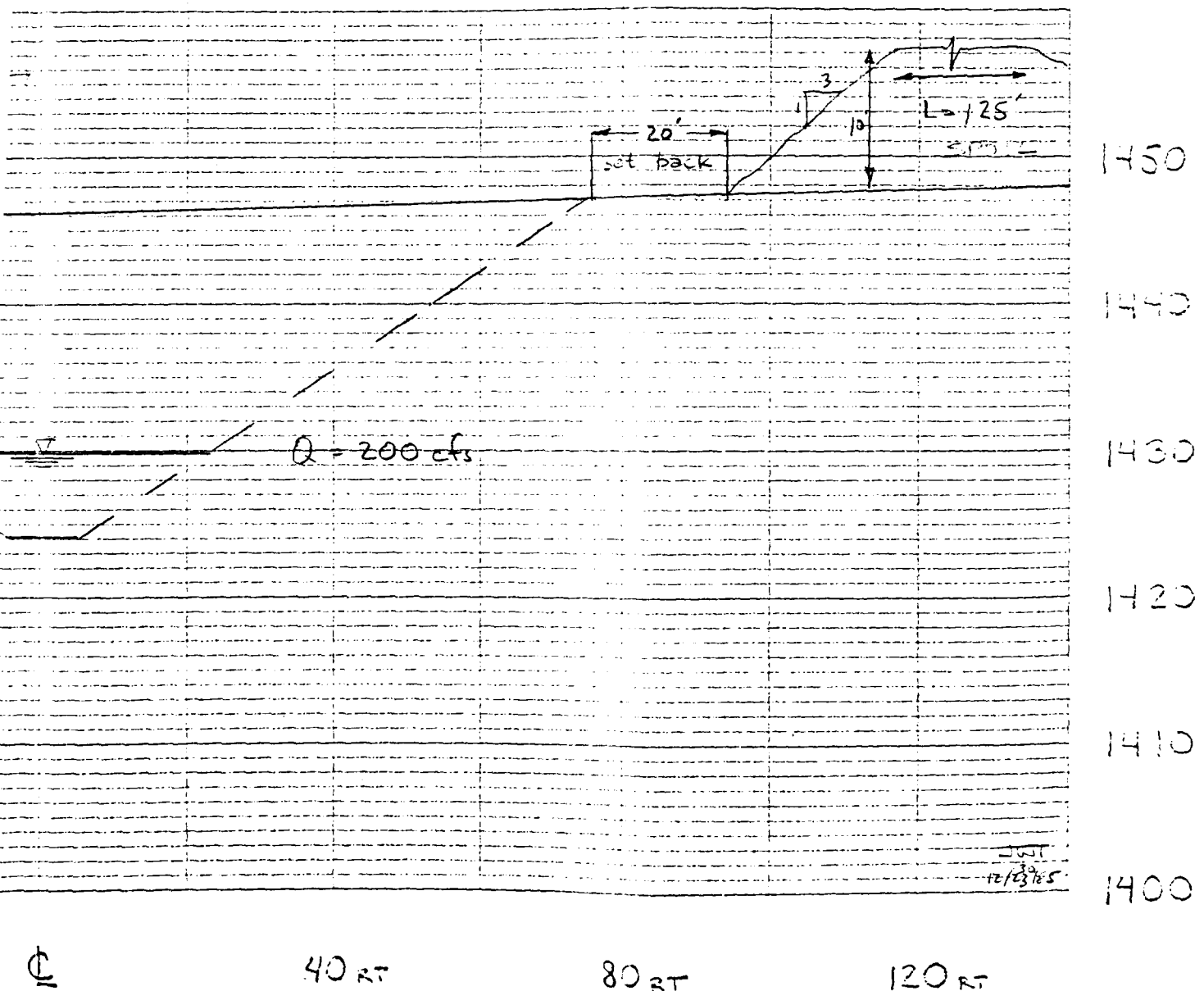
CASE 2P

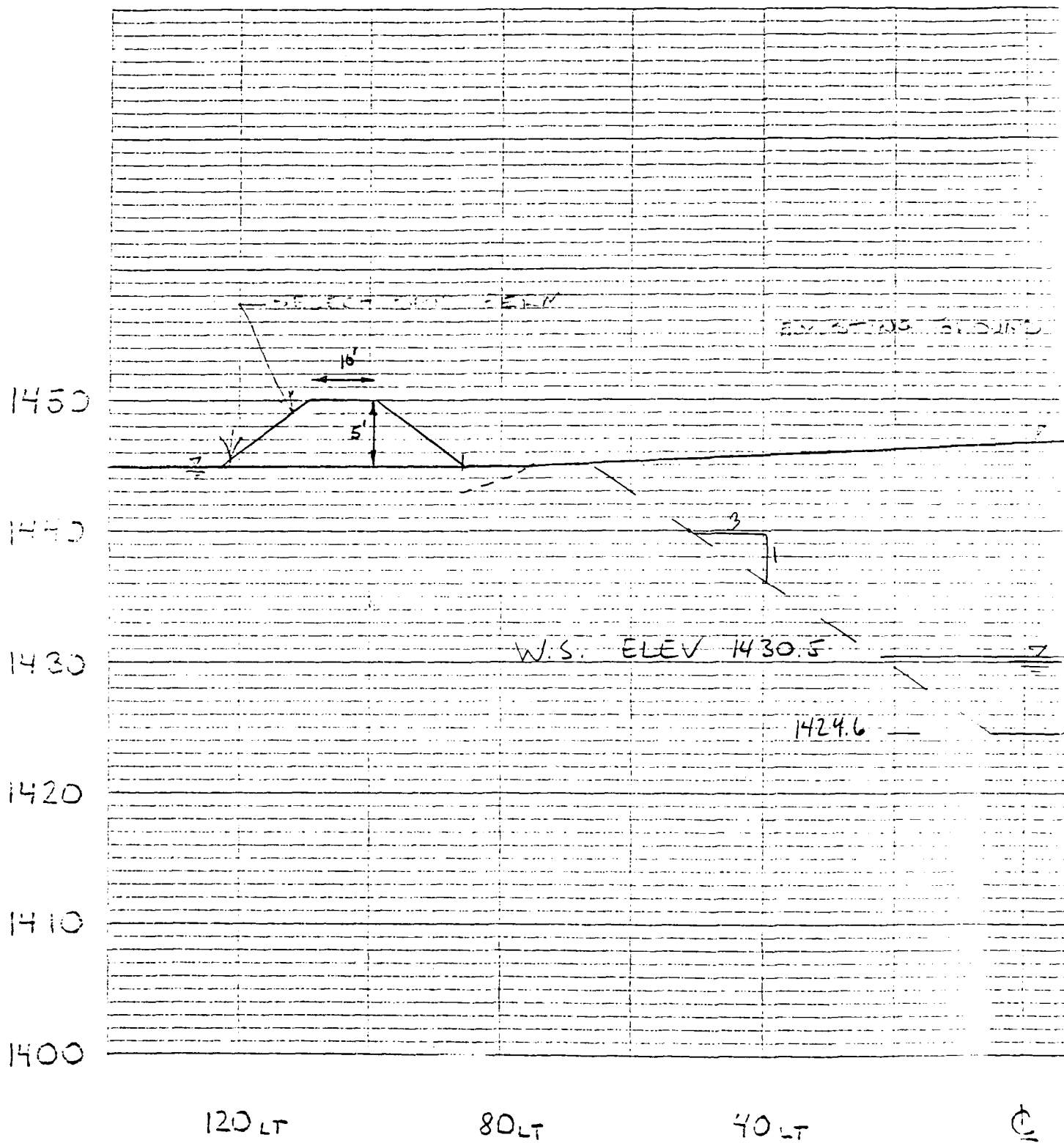
CROSS SECTION STA 210+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 2P CROSS SECTION STA 244+00

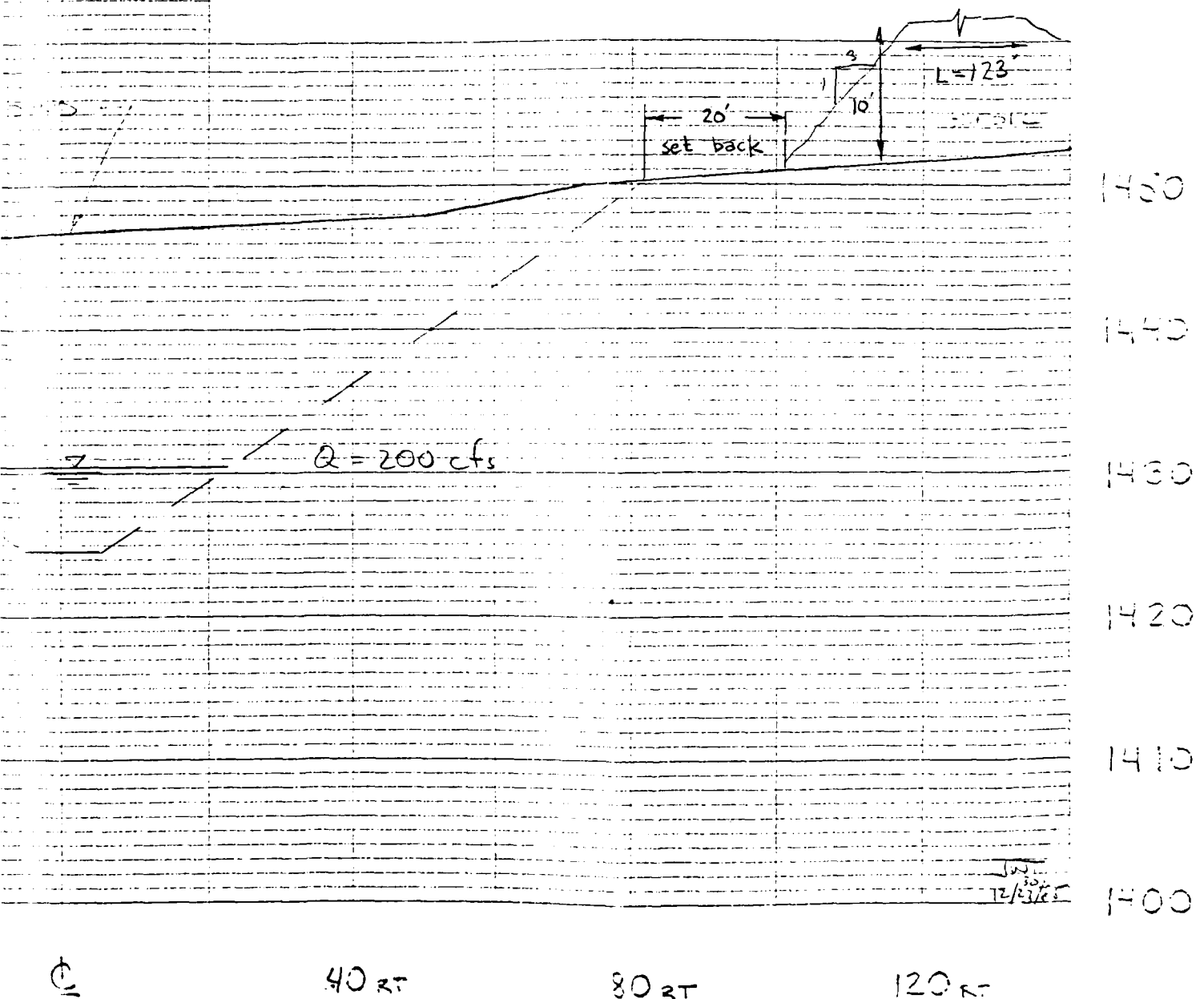




# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2P

CROSS SECTION STA 275+00



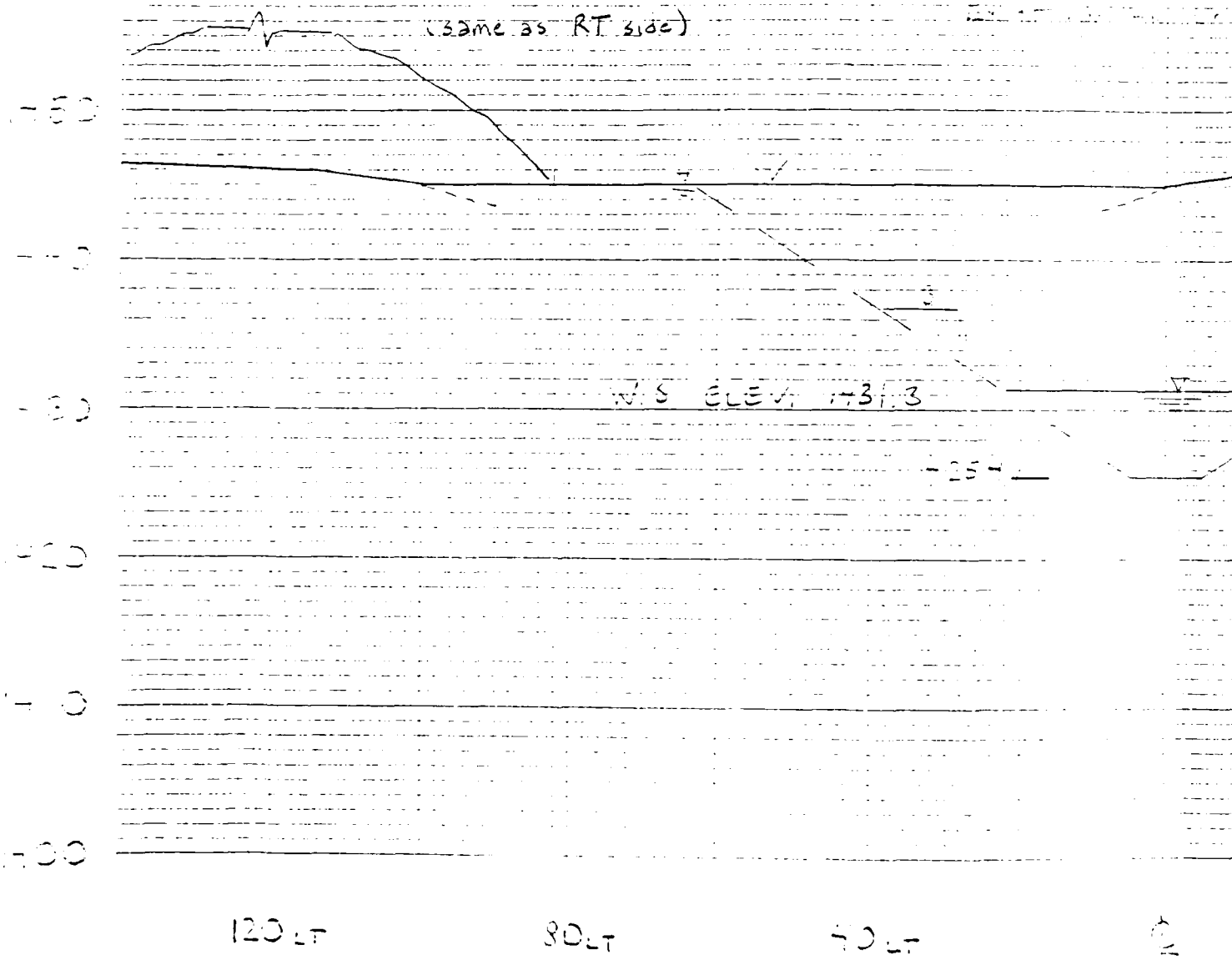
0

40 RT

80 RT

120 RT

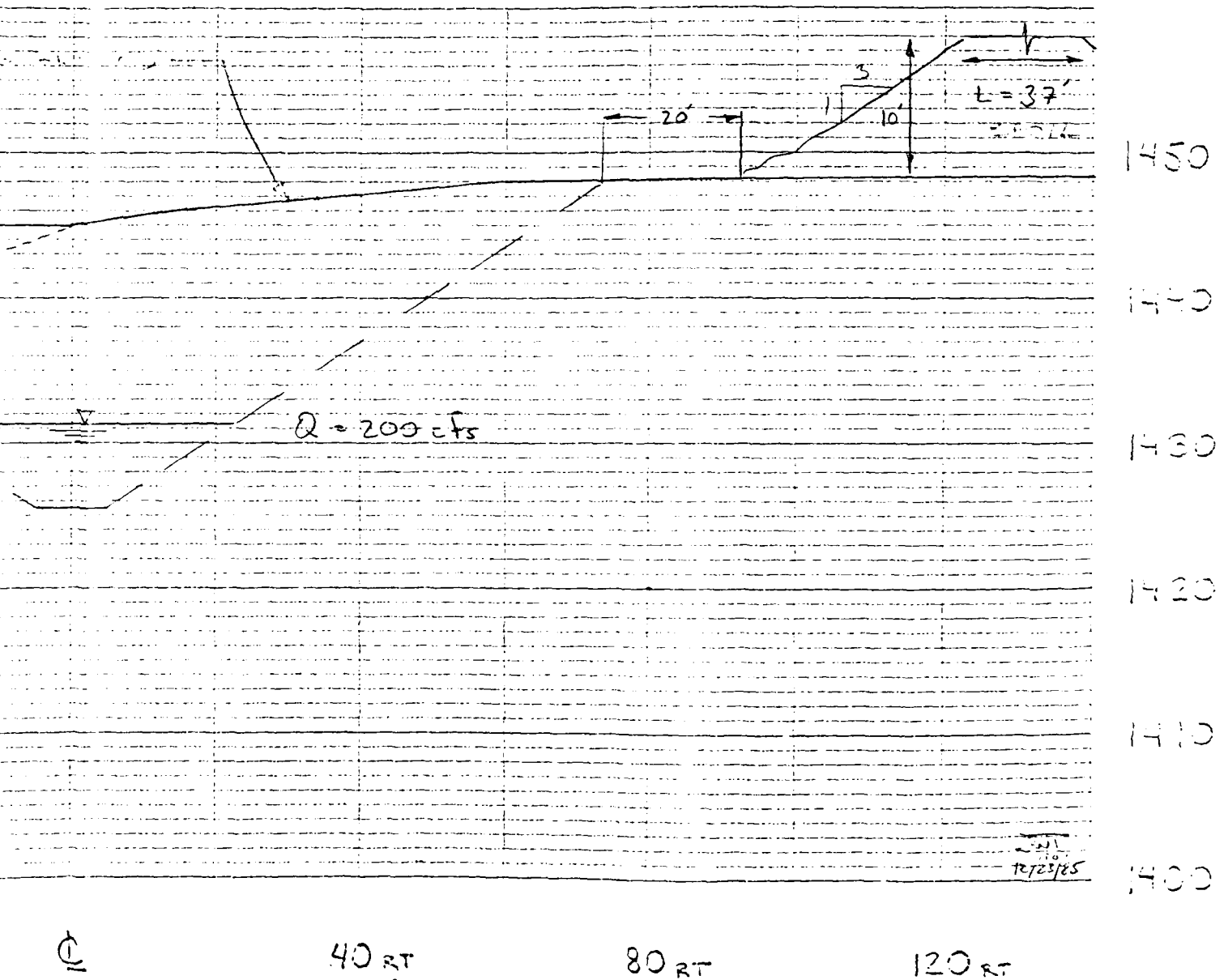




# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

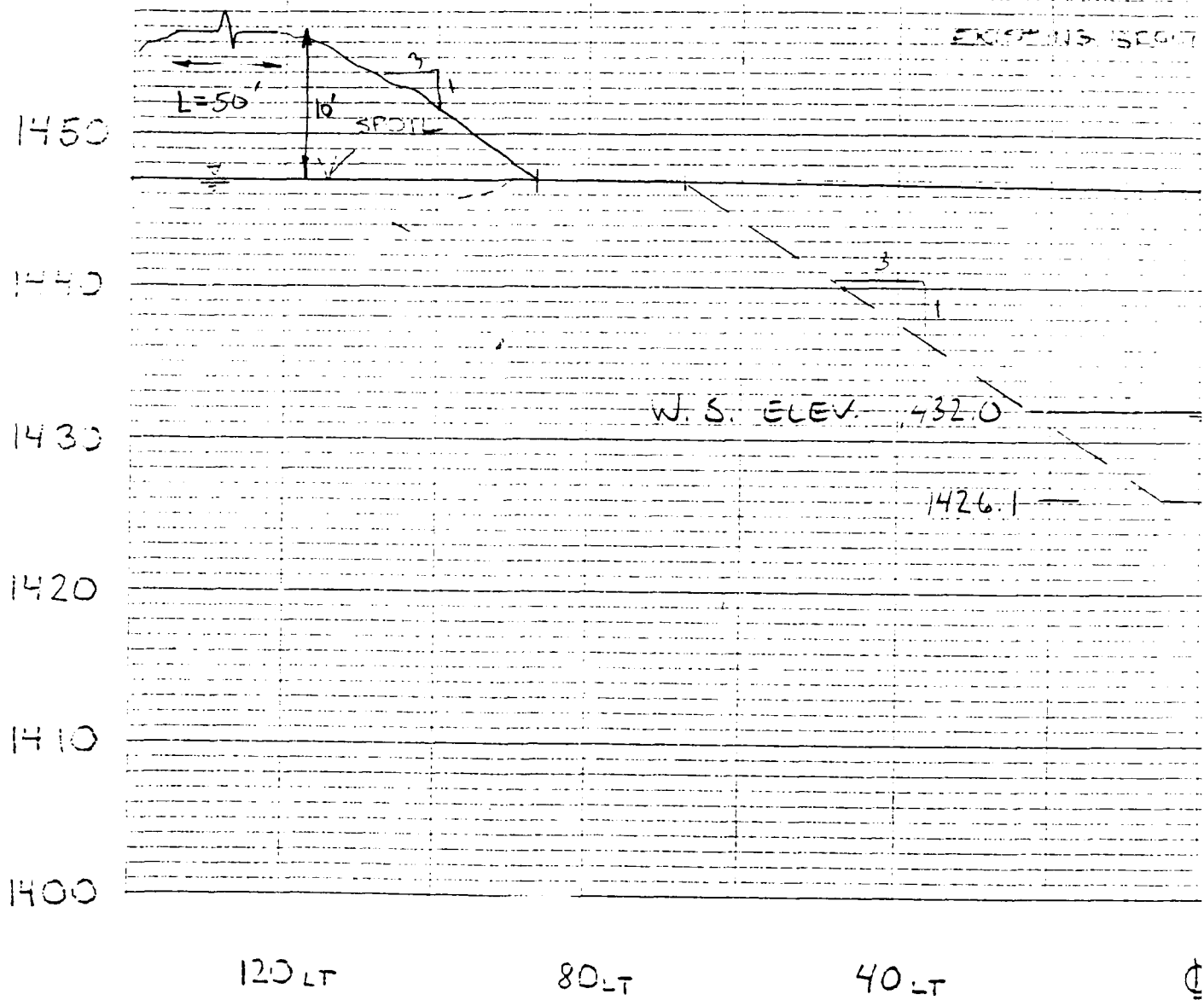
CASE 2P

CROSS SECTION STA 304+00



12/23/85

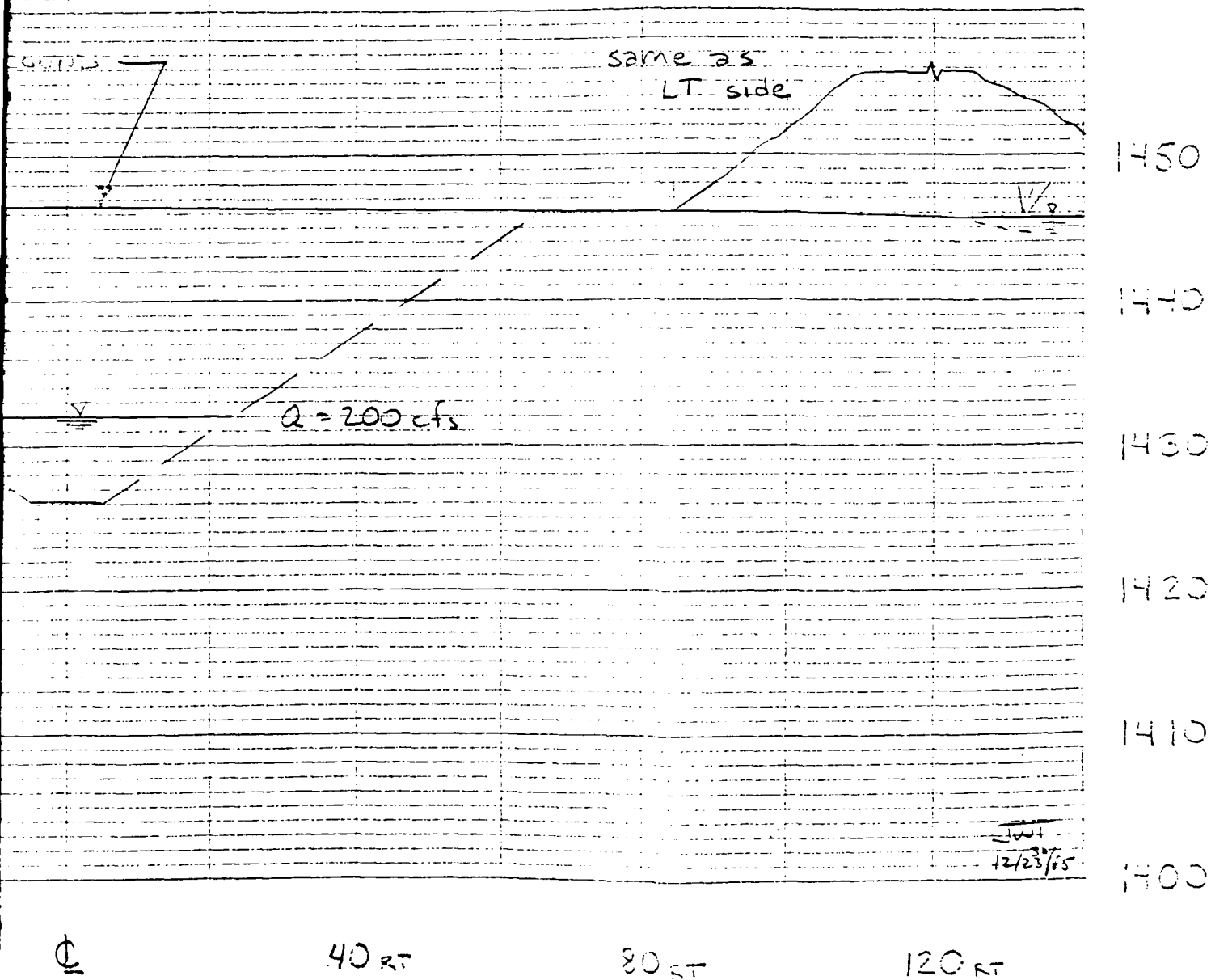
PLATE C-1

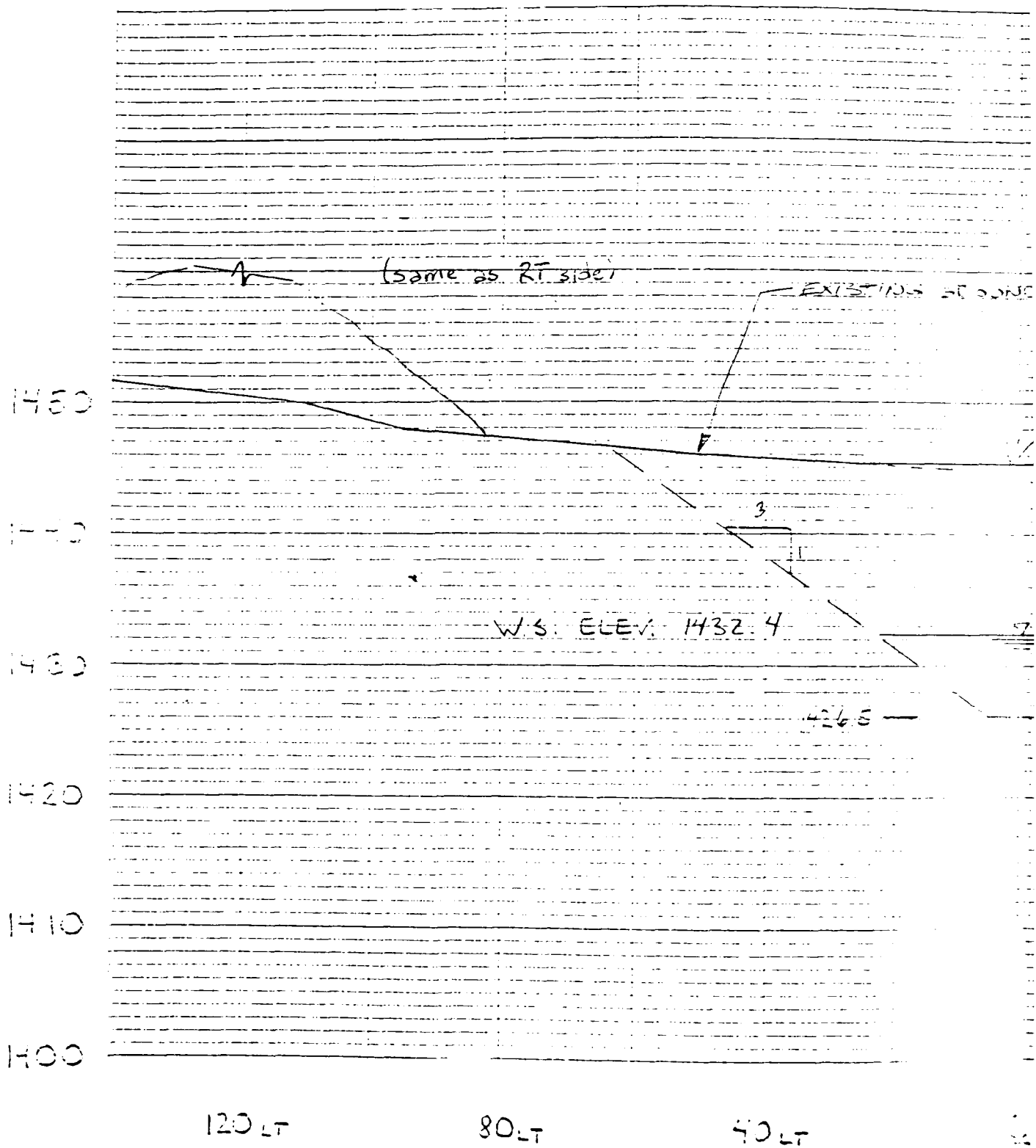


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

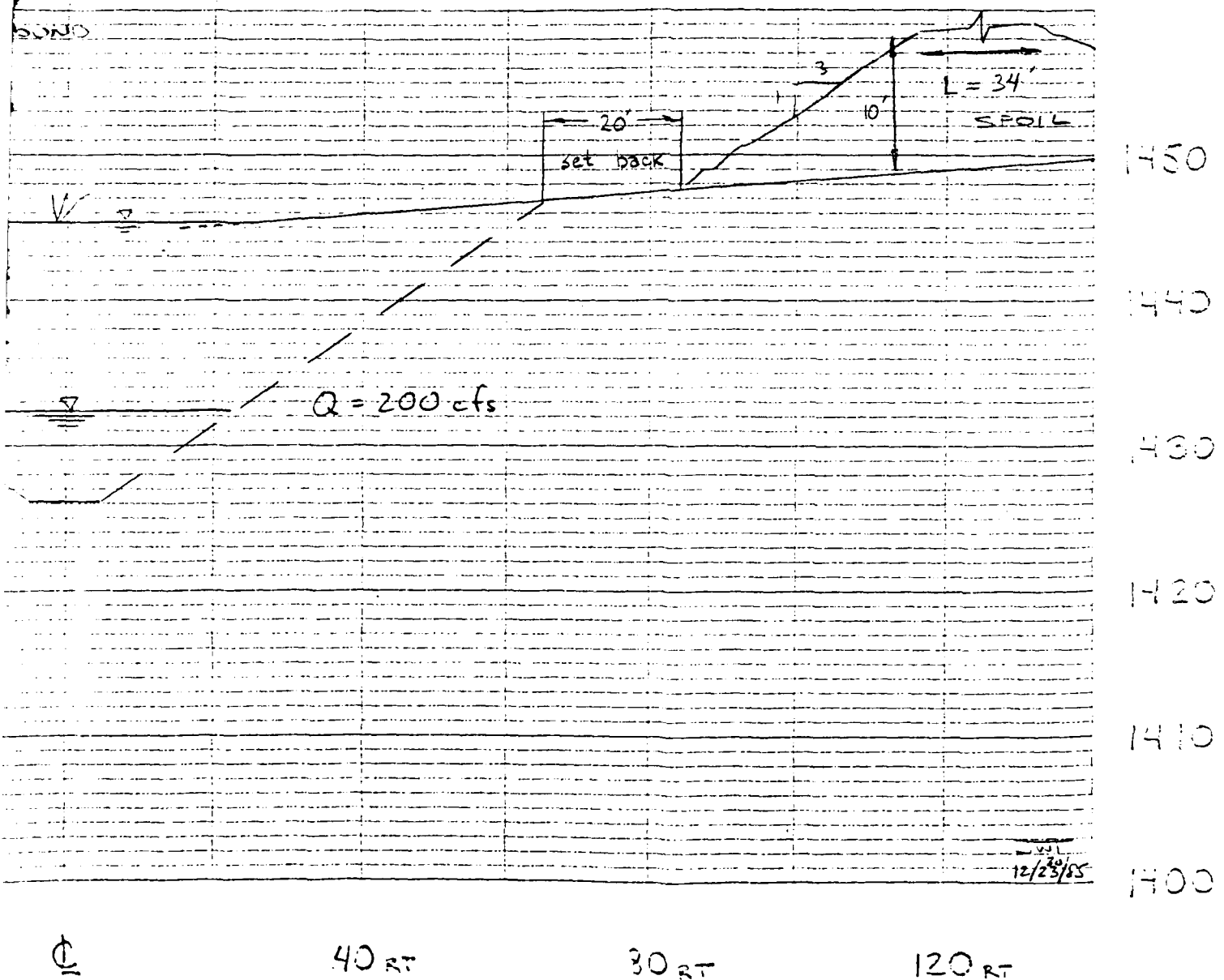
CASE 2P

CROSS SECTION STA 345+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 2P CROSS SECTION STA 370+00



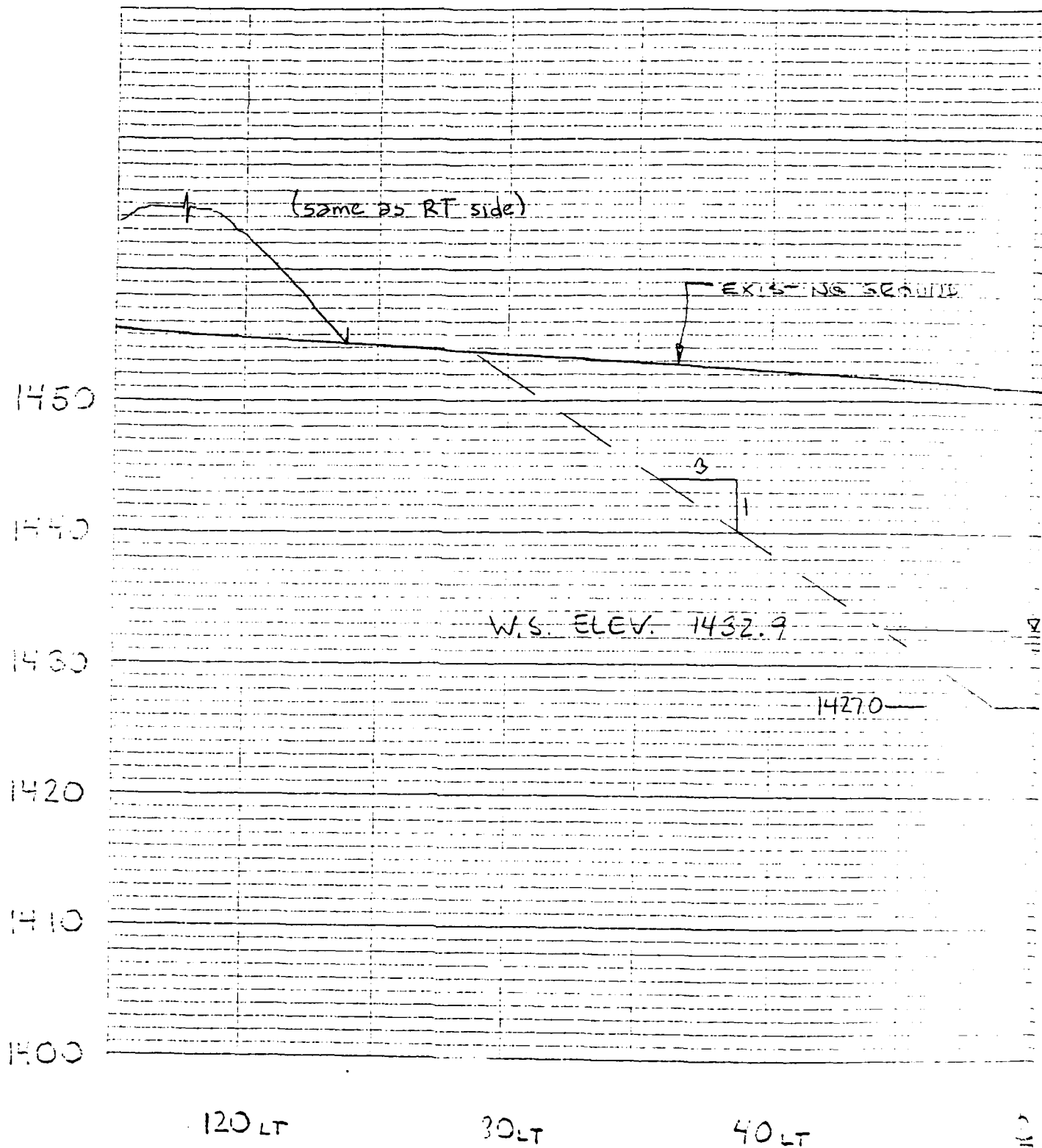
①

40 RT

30 RT

120 RT

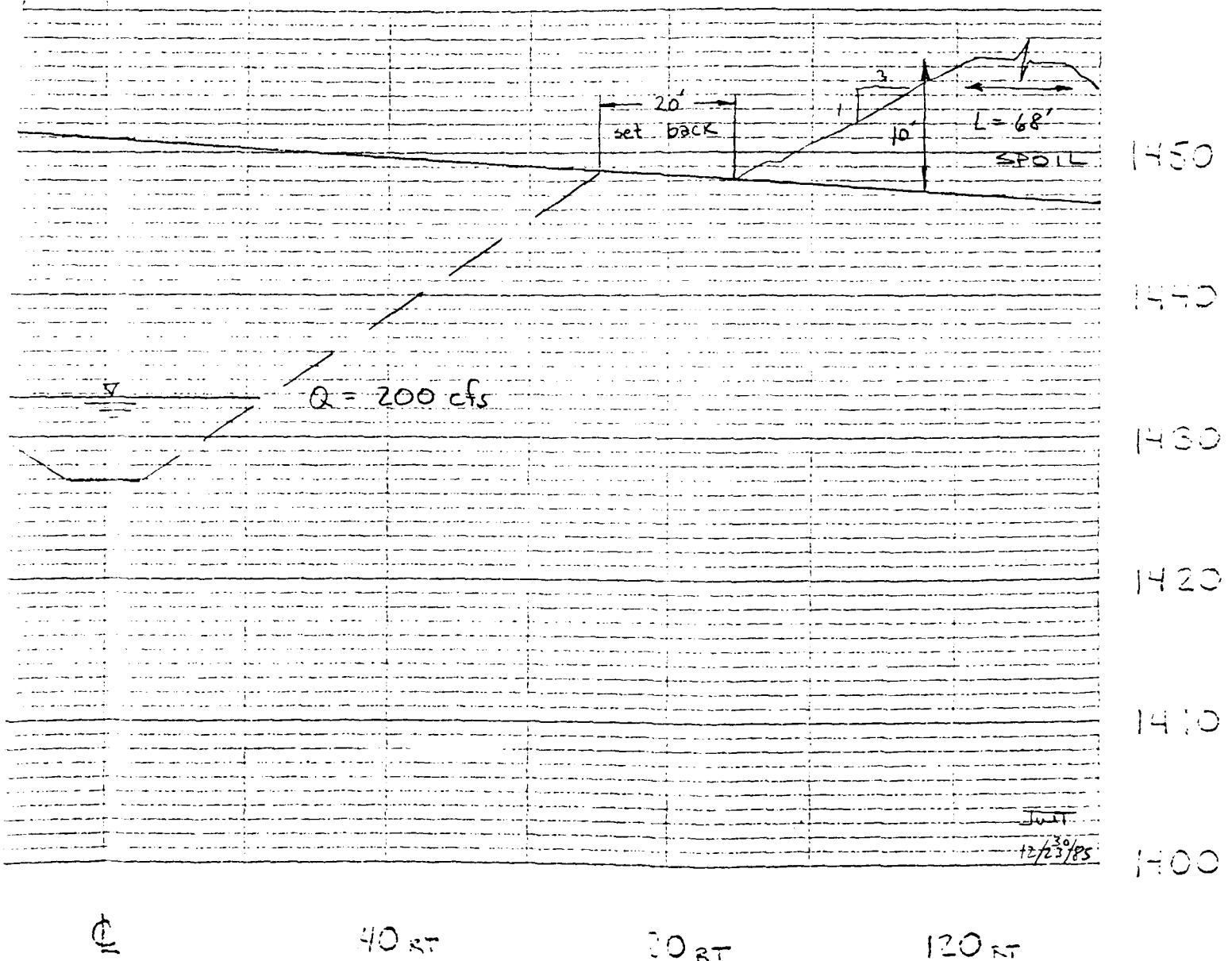
Q = 200 cfs



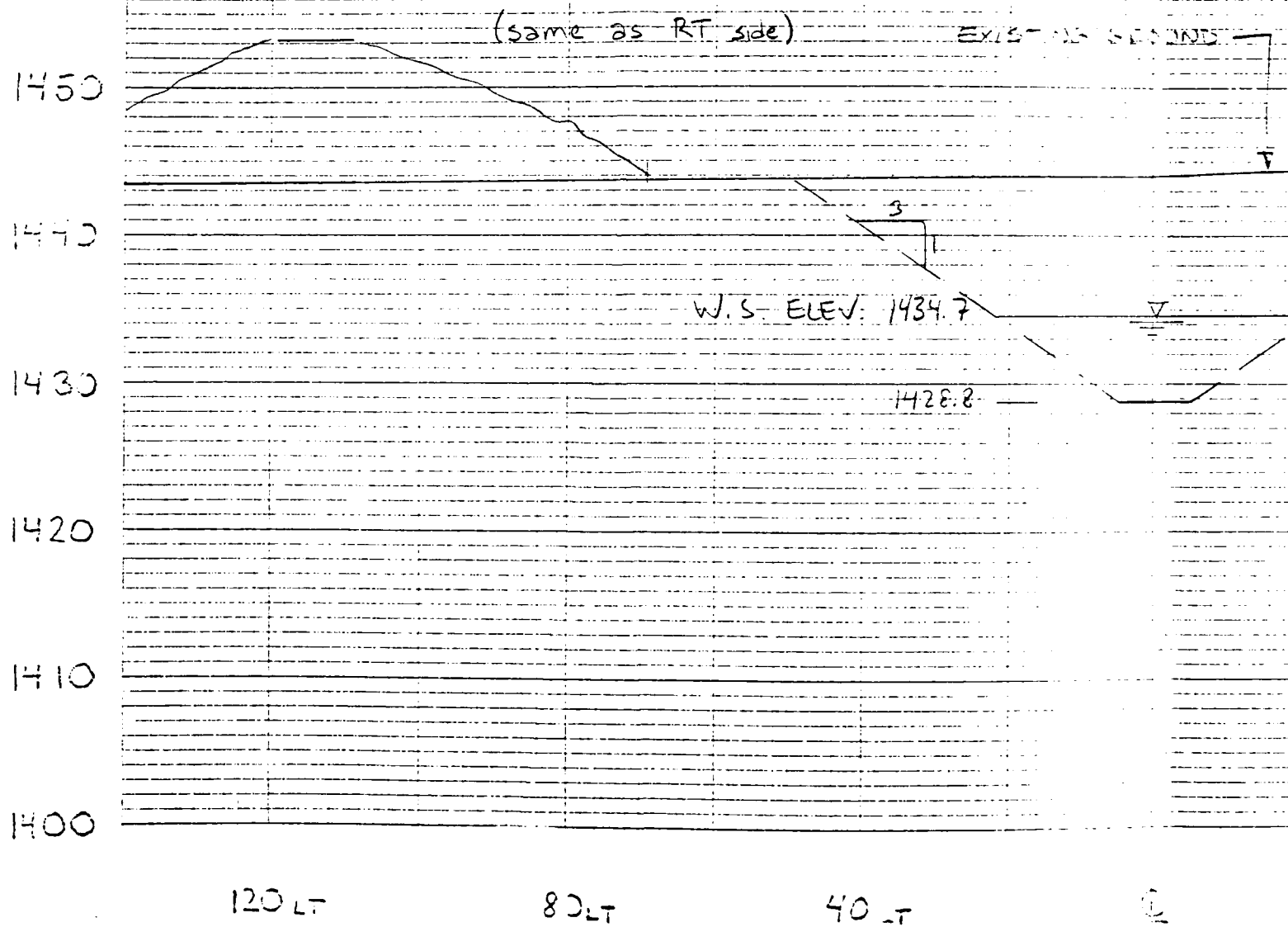
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE 2P

CROSS SECTION STA 398+00



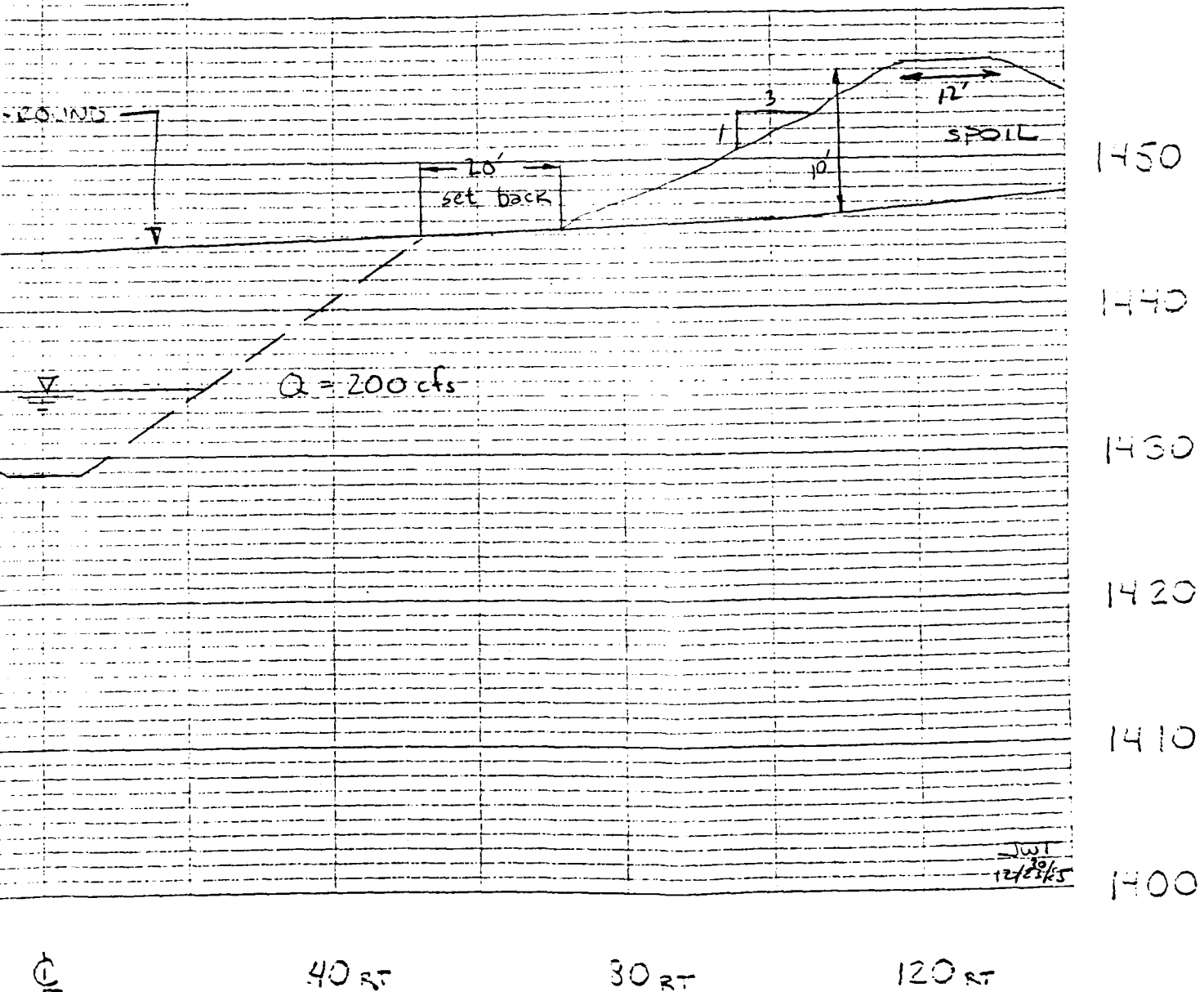


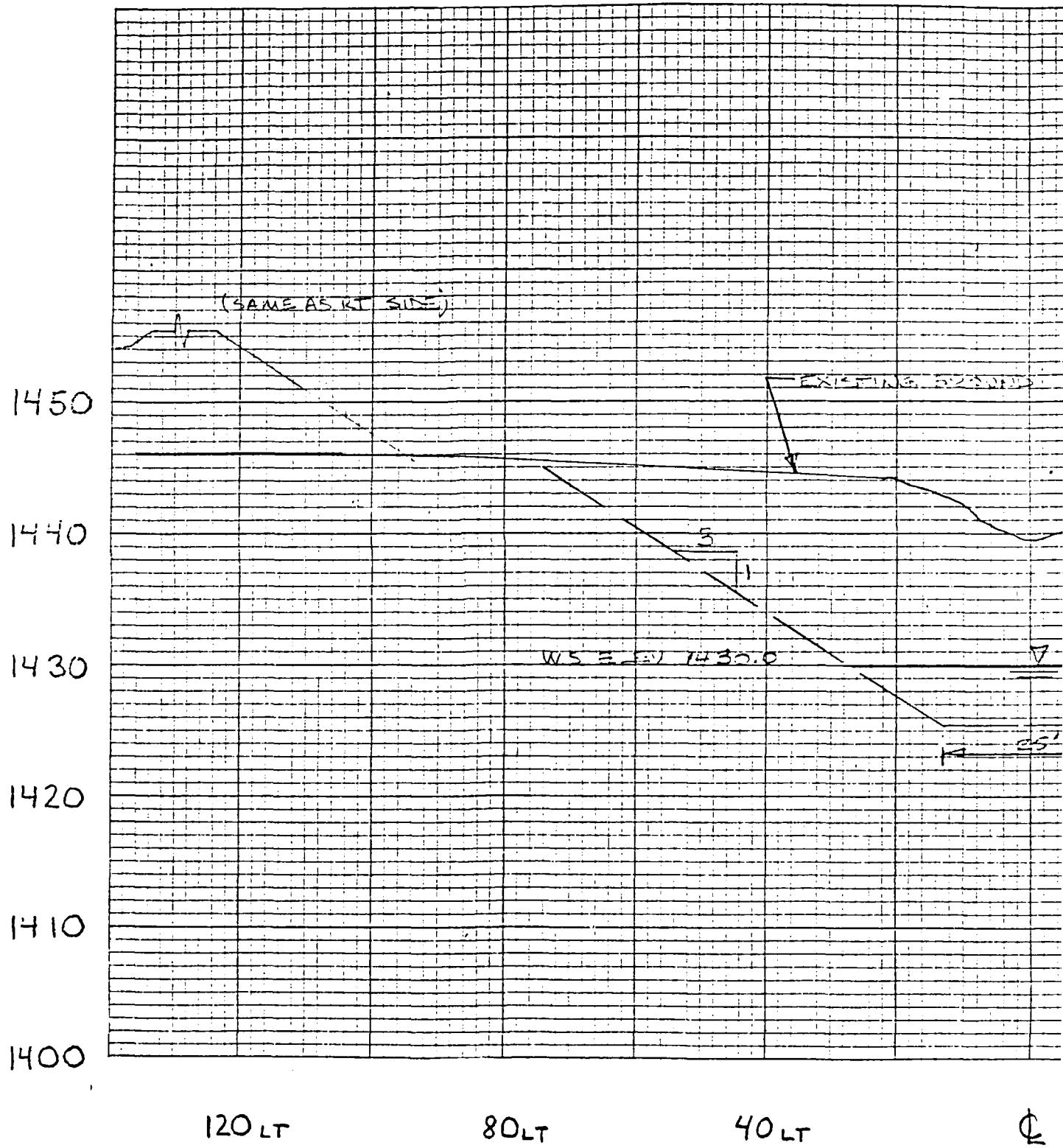


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 2P

CROSS SECTION STA 485+00







1450

1440

1430

1420

1410

1400

120<sub>LT</sub>

80<sub>LT</sub>

40<sub>LT</sub>

E

(Same as RT side)

EXISTING SOUND

W.S. ELEV 1410.2

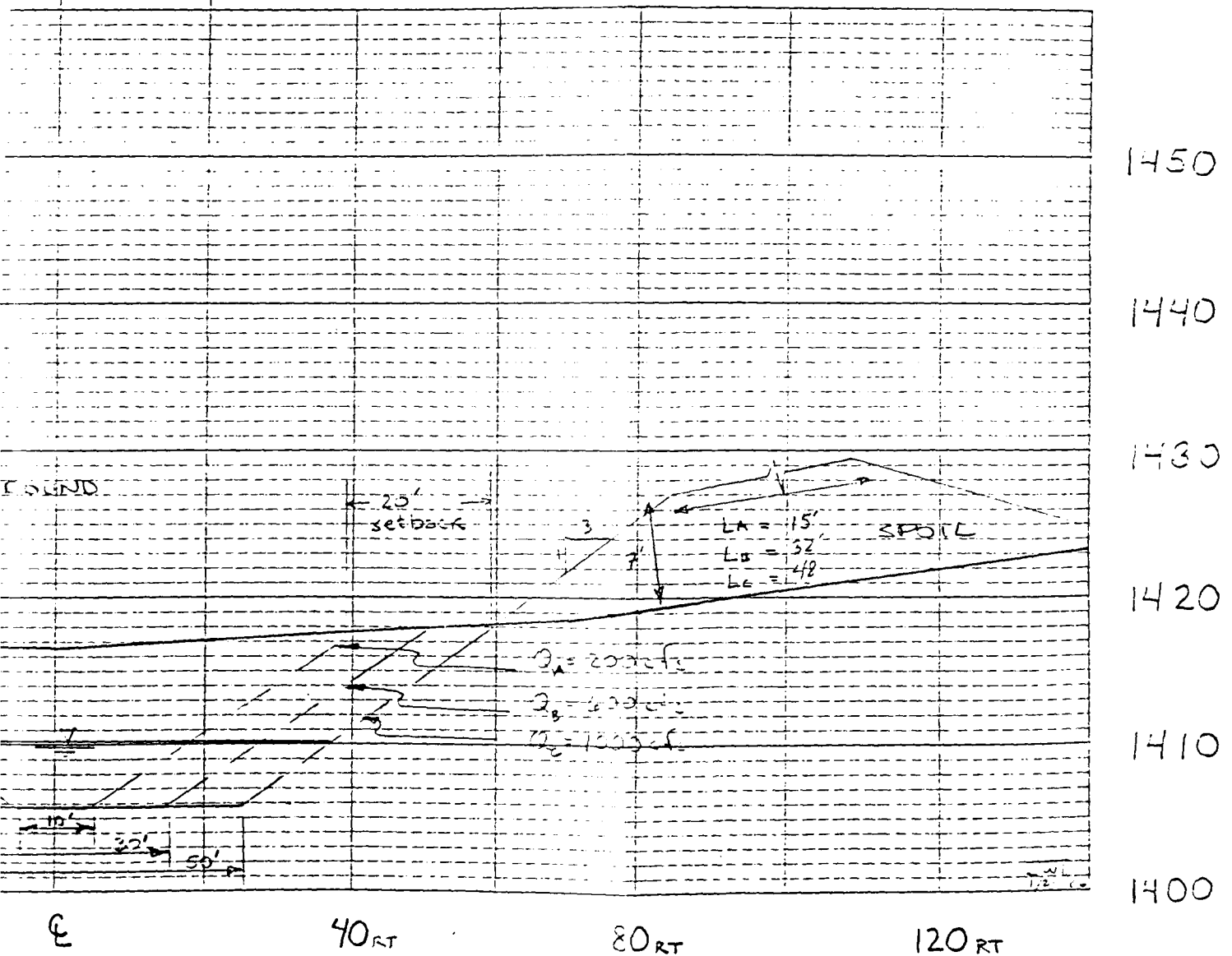
1405.8

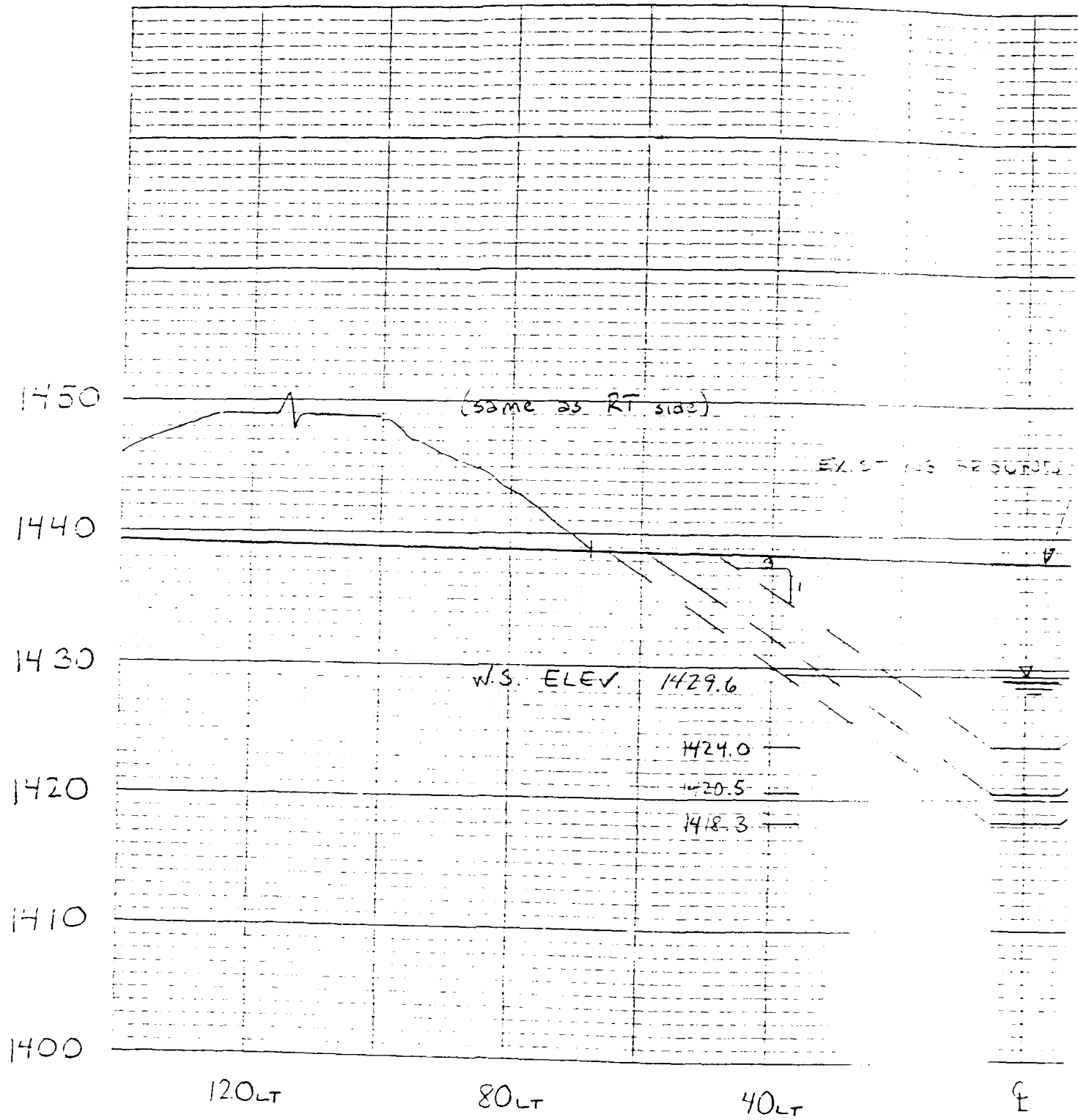
10'

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

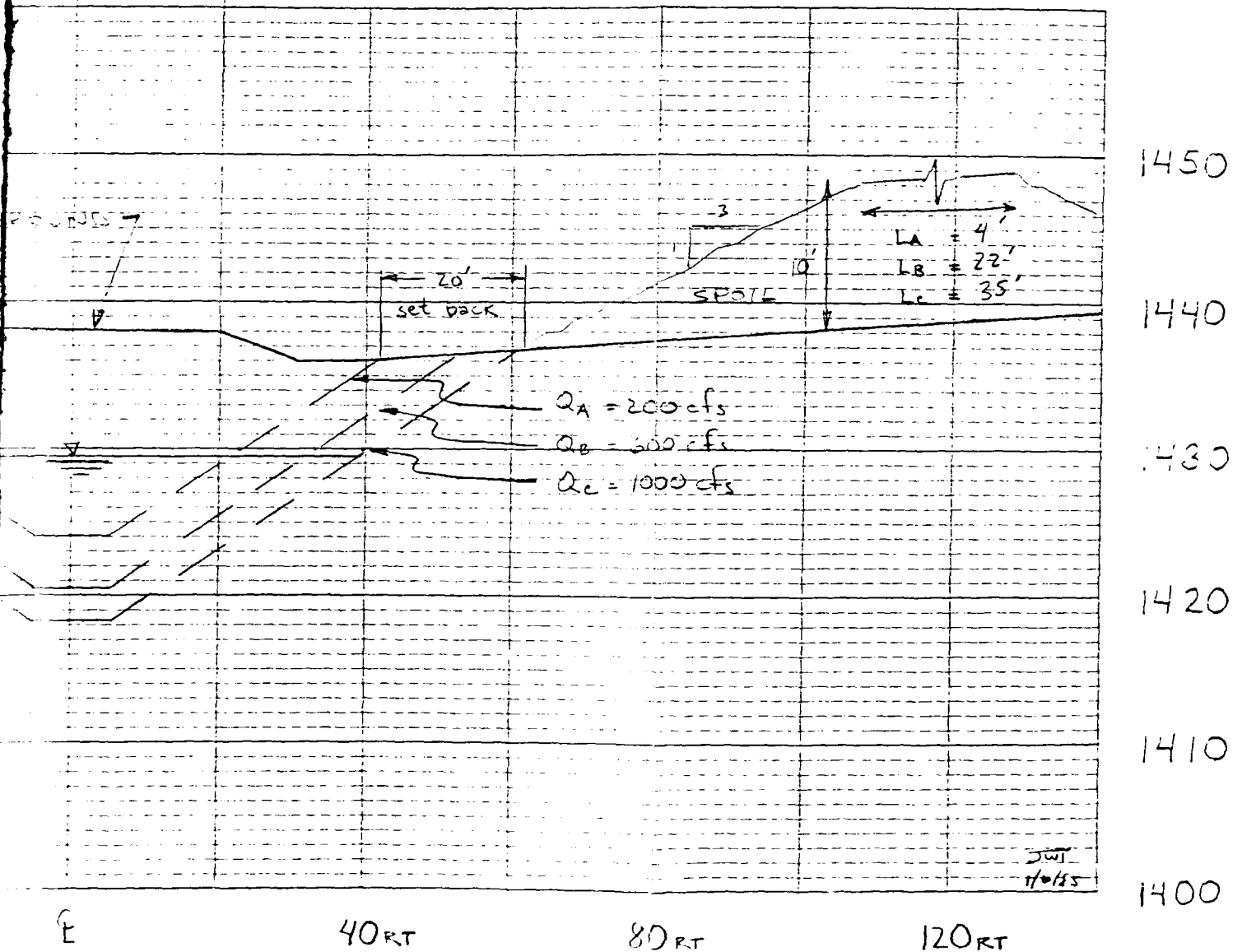
CASE 3A, 2C

CROSS SECTION STA 25+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 3A, B, C  
CROSS SECTION STA 70+00





1450

EXTENDING GRD US 7

1440

SELECT SPOIL BERM

1430

1420

1410

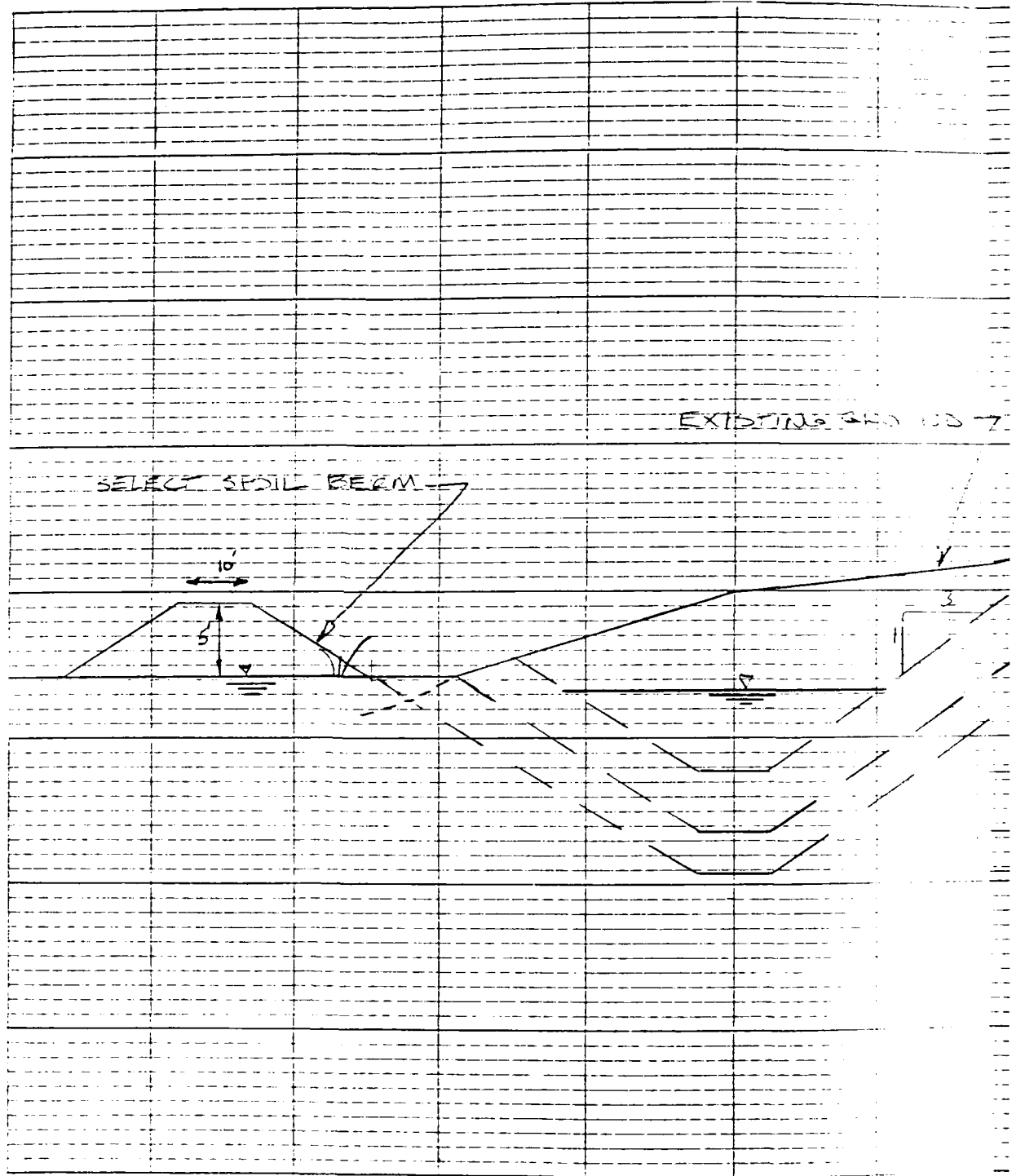
1400

80LT

40LT

E

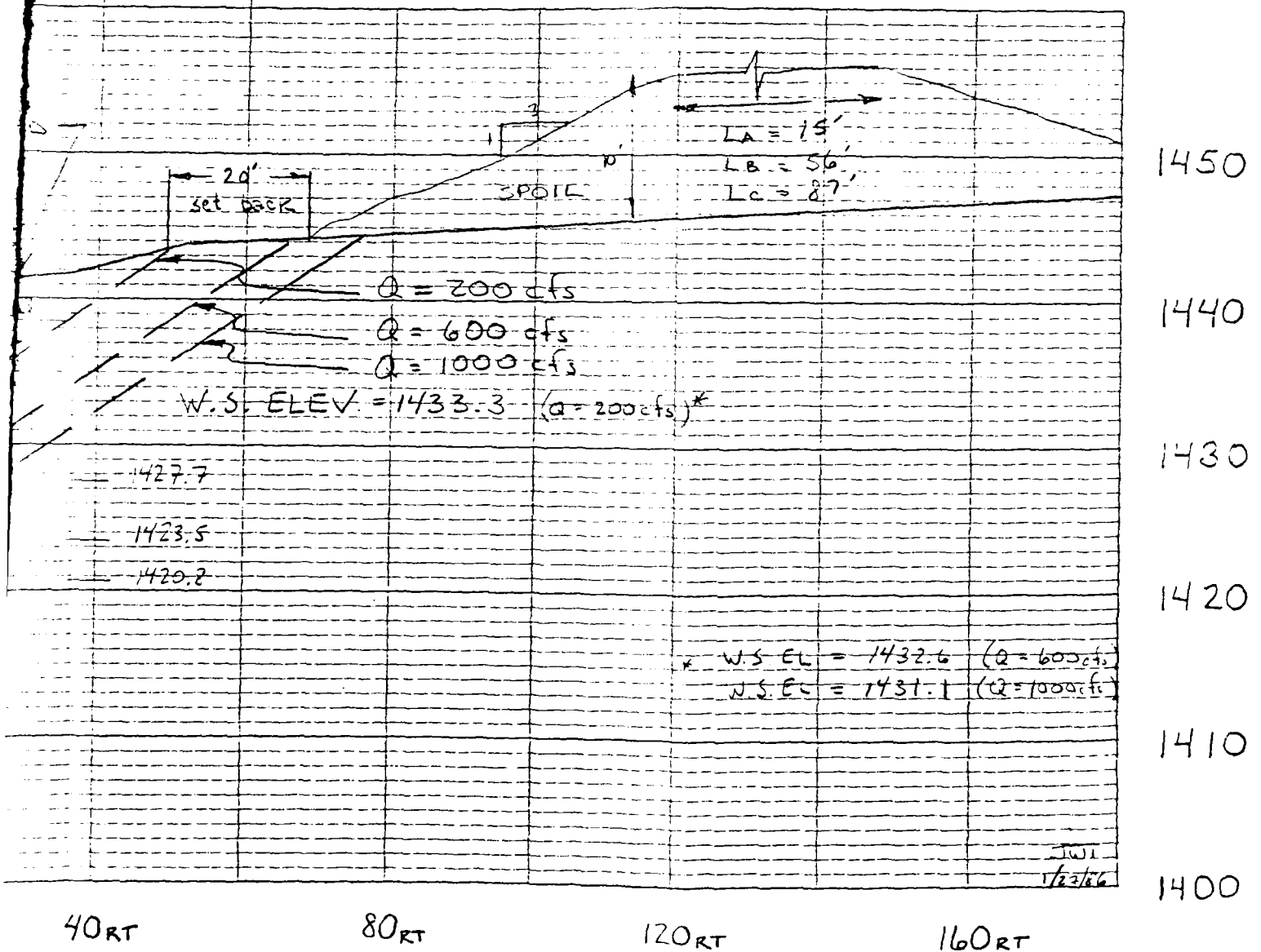
4



# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 3A, B, & C

CROSS SECTION STA 120+00



1450

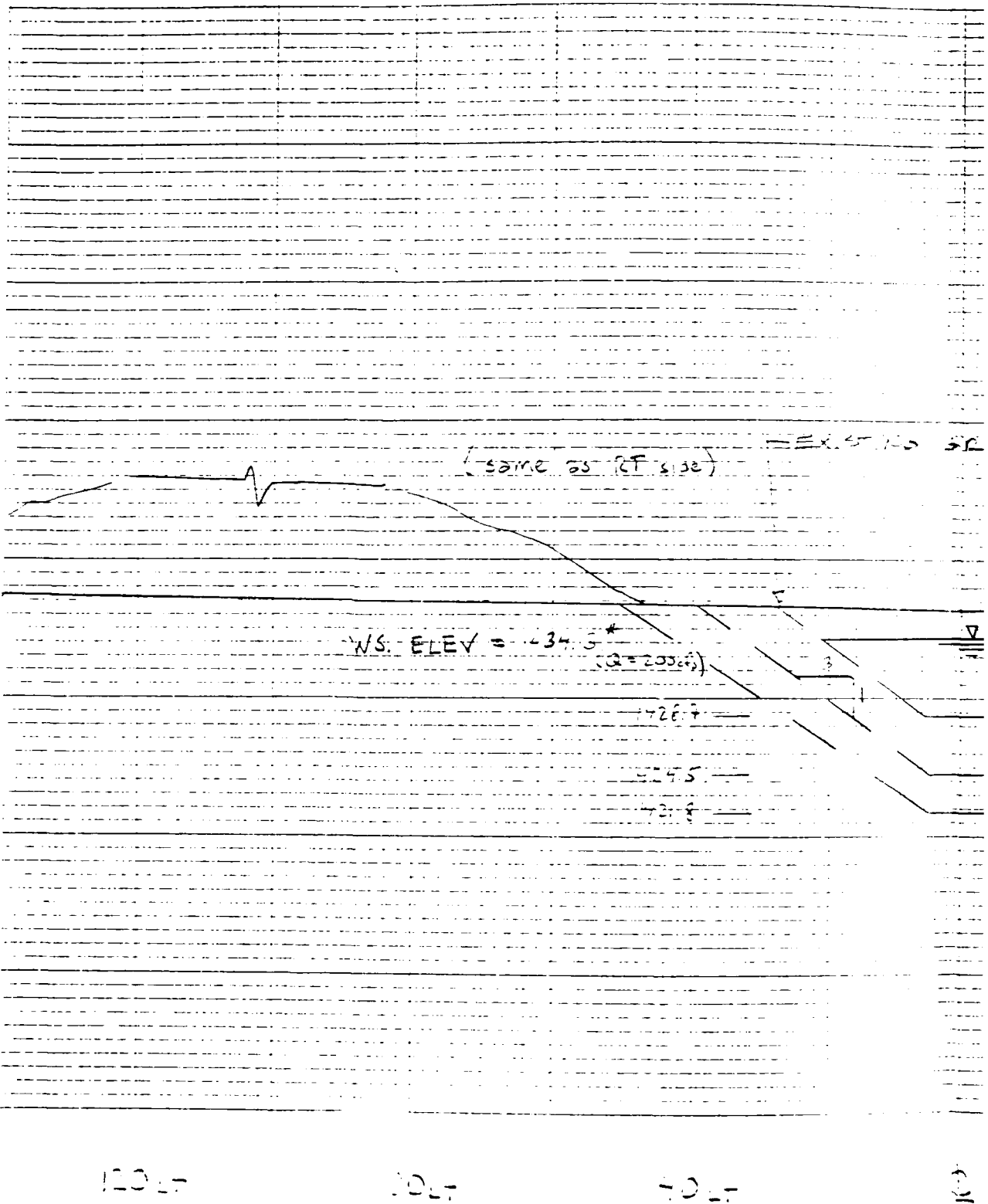
1440

1430

1420

1410

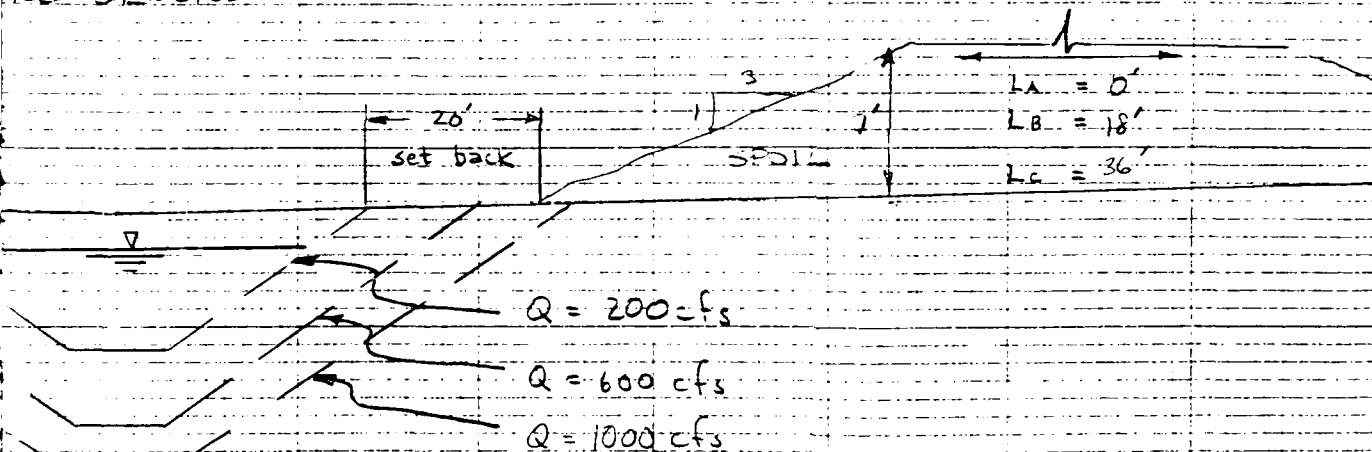
1400



# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 3A, B, & C  
CROSS SECTION STA 170+00

AS GROUND

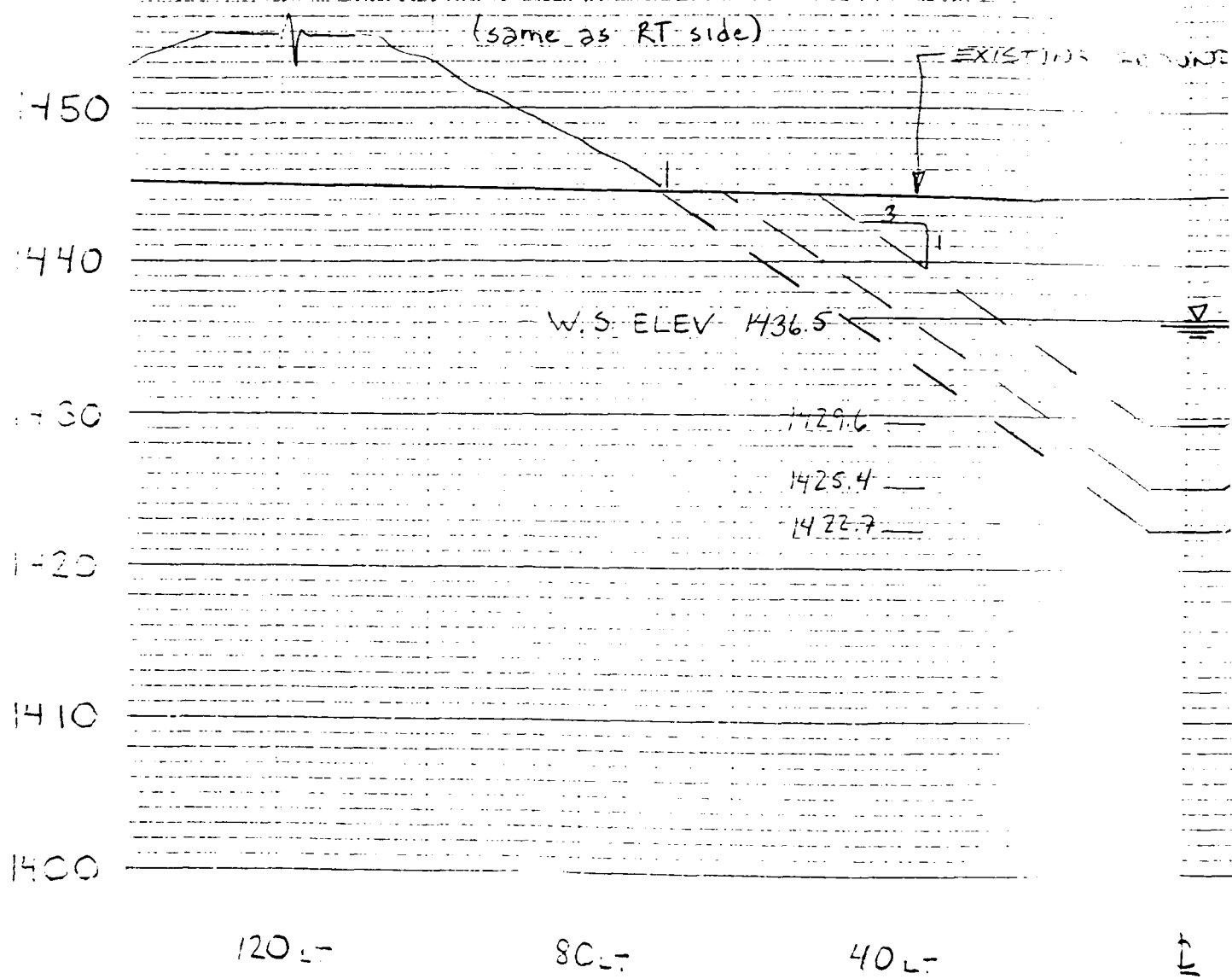


$$* \text{W.S. ELEV} = 1433.6 (Q=600 \text{ cfs})$$

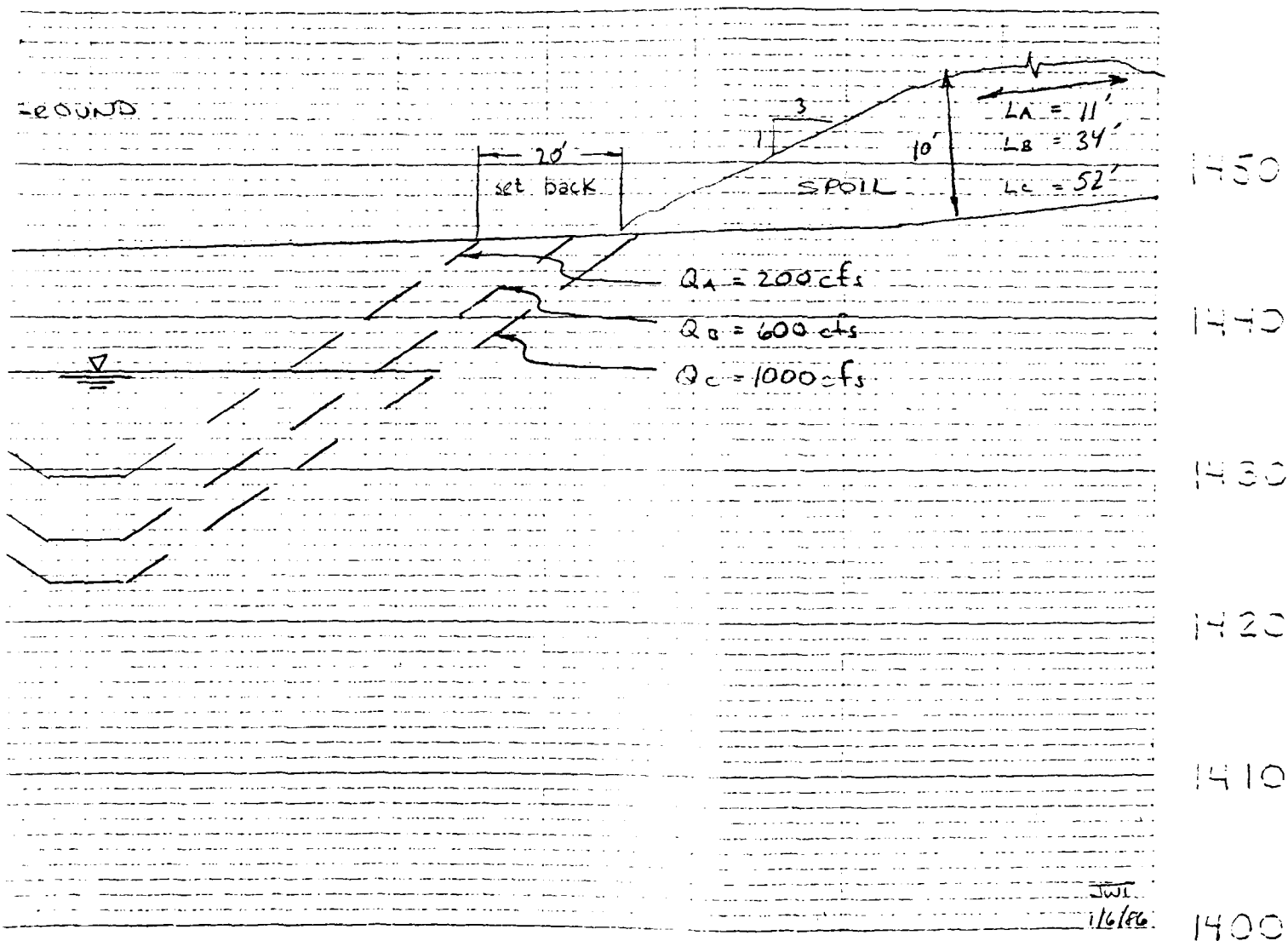
$$\text{W.S. ELEV} = 1433.1 (Q=1000 \text{ cfs})$$

JWT

1/6/66



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 3A, B, & C  
CROSS SECTION STA 210+00

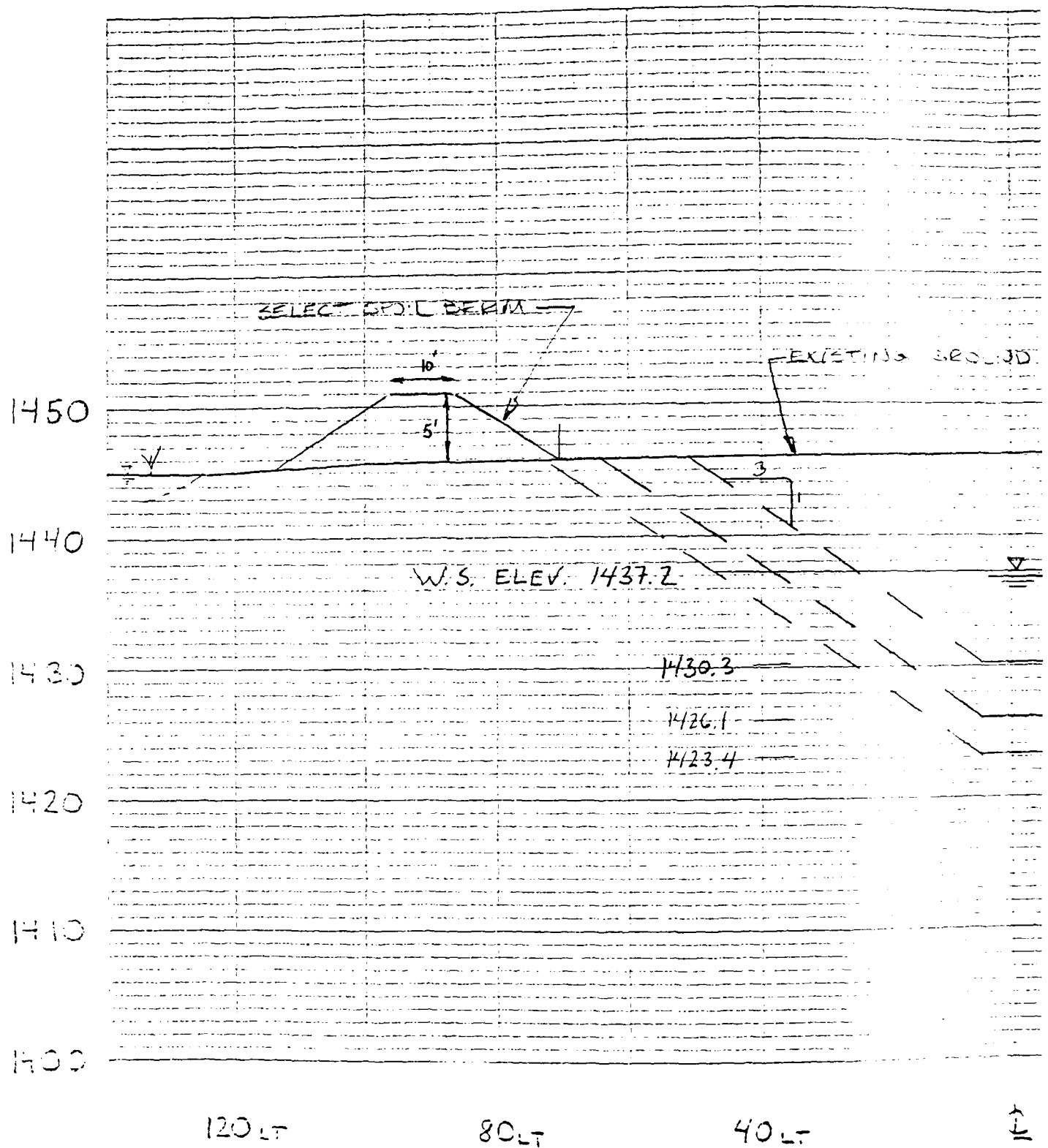


Q

40 RT

80 R-

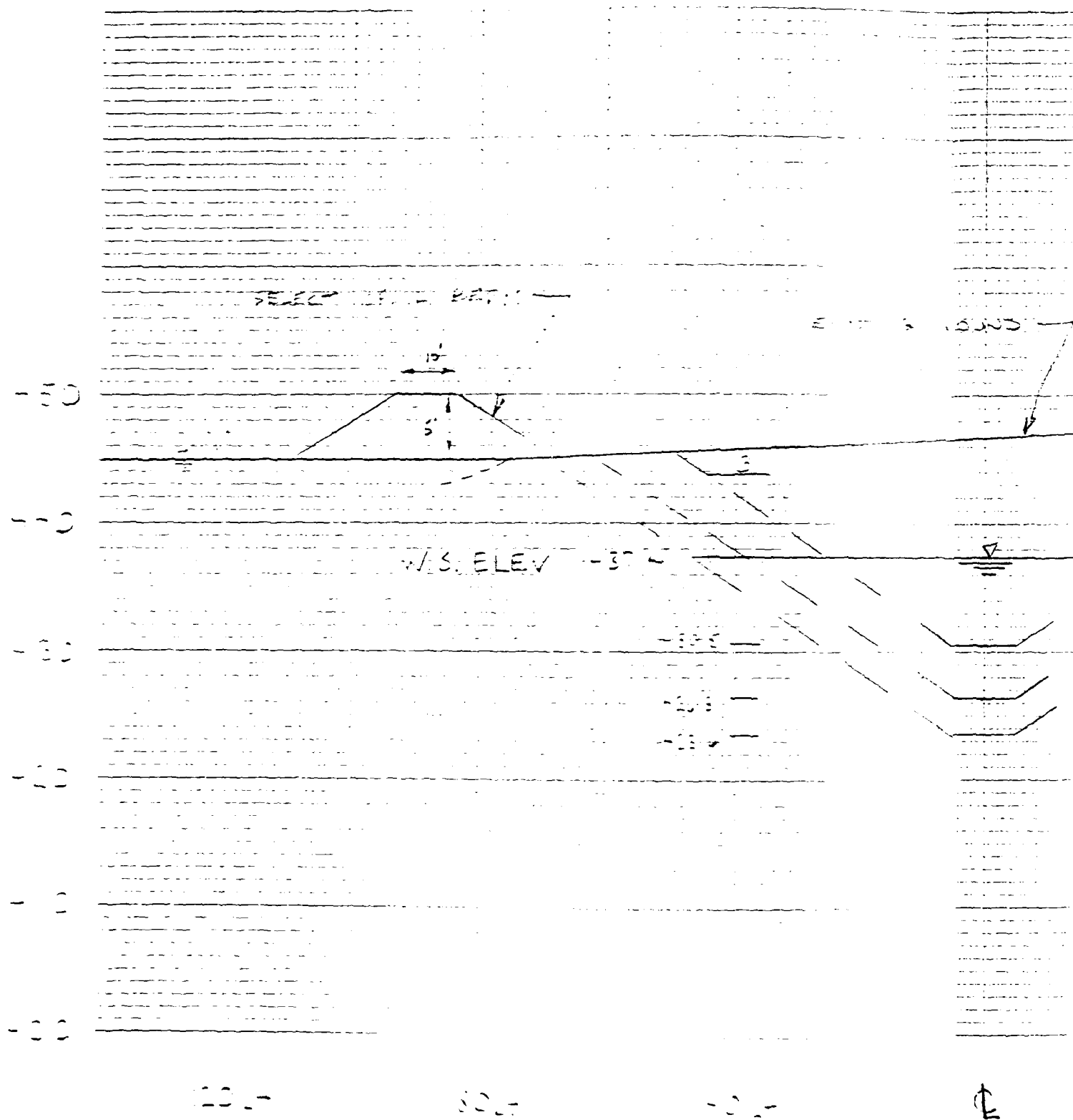
120 ST



CASE 3A, B, & C  
CROSS SECTION STA 244+00

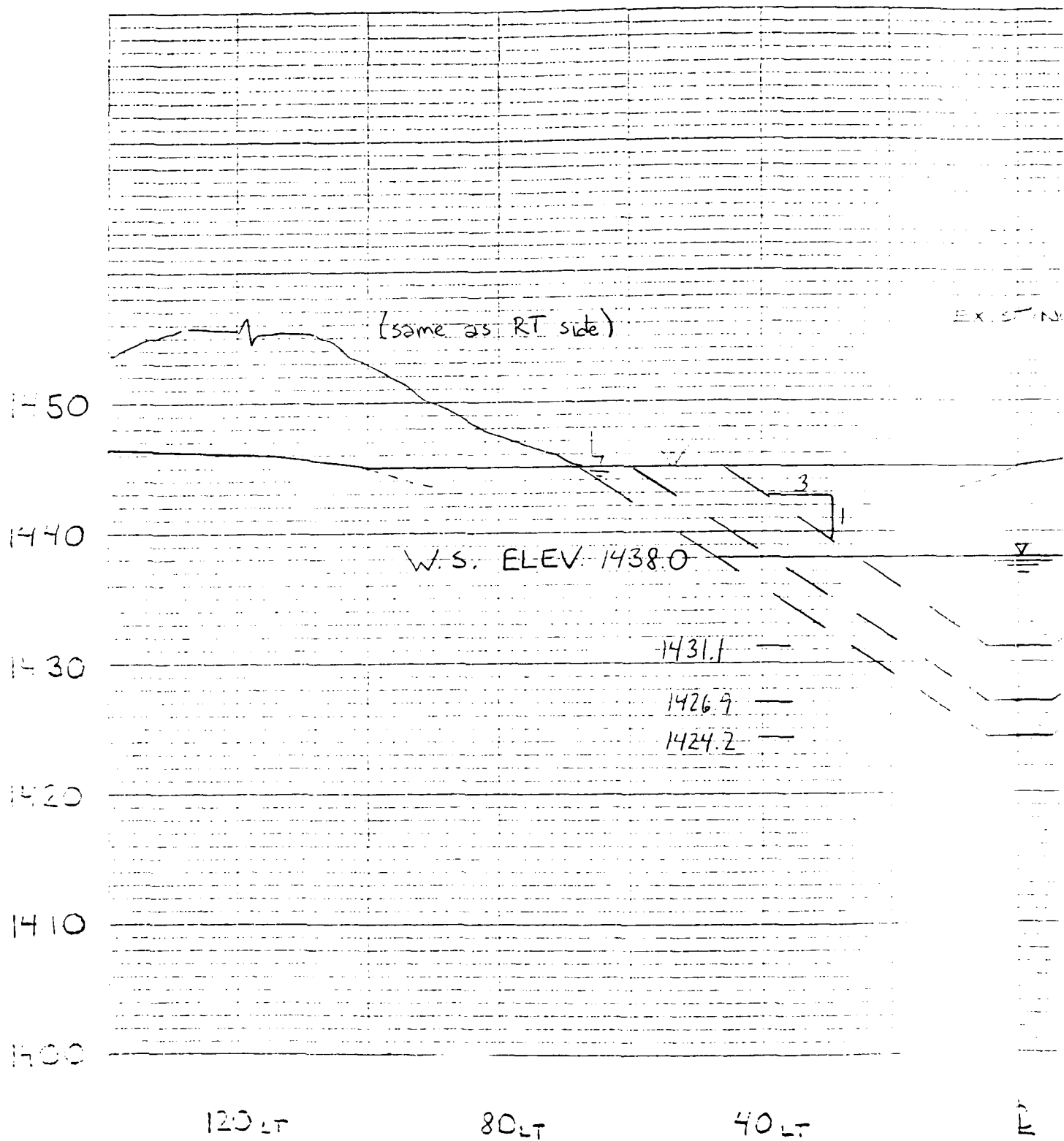




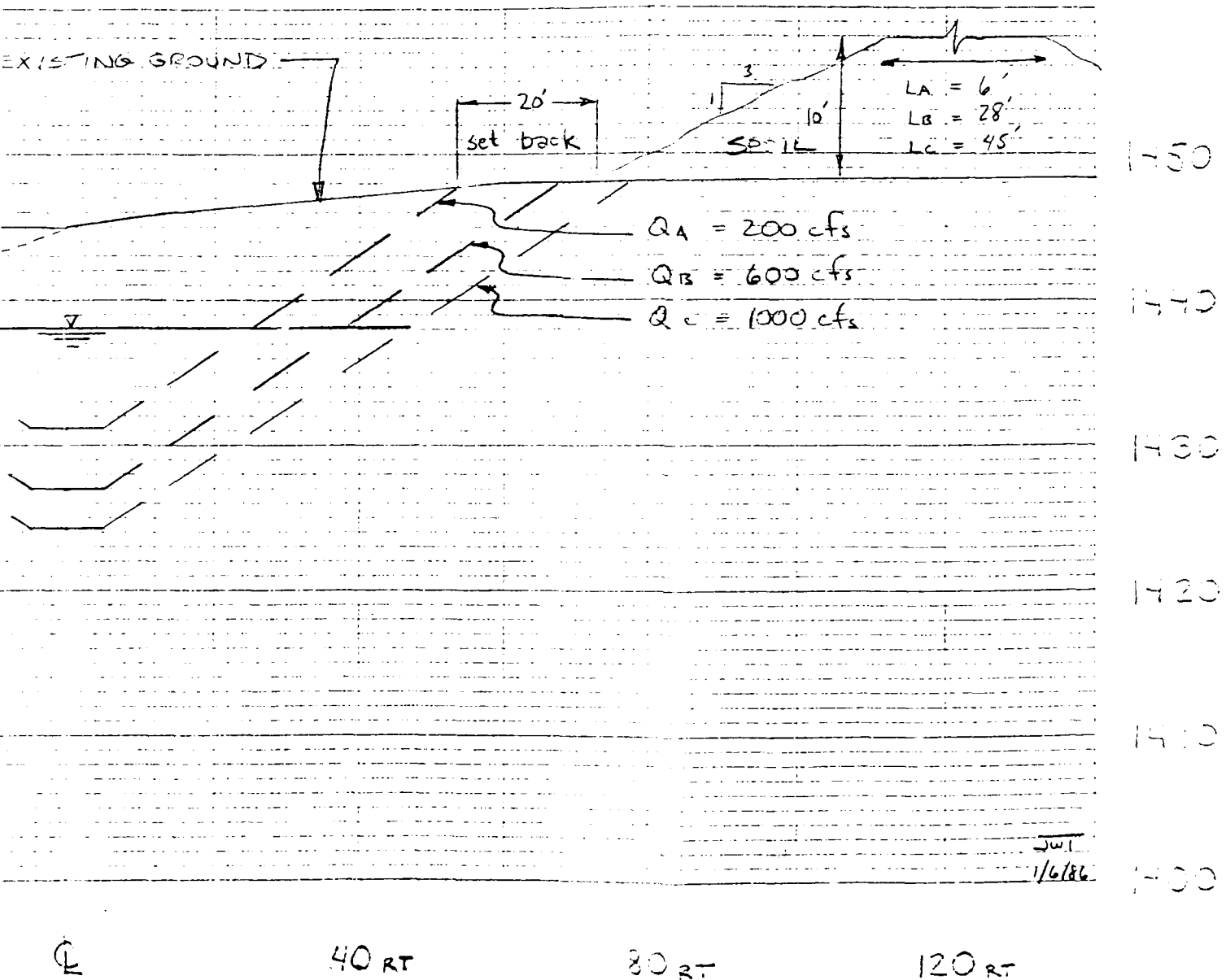


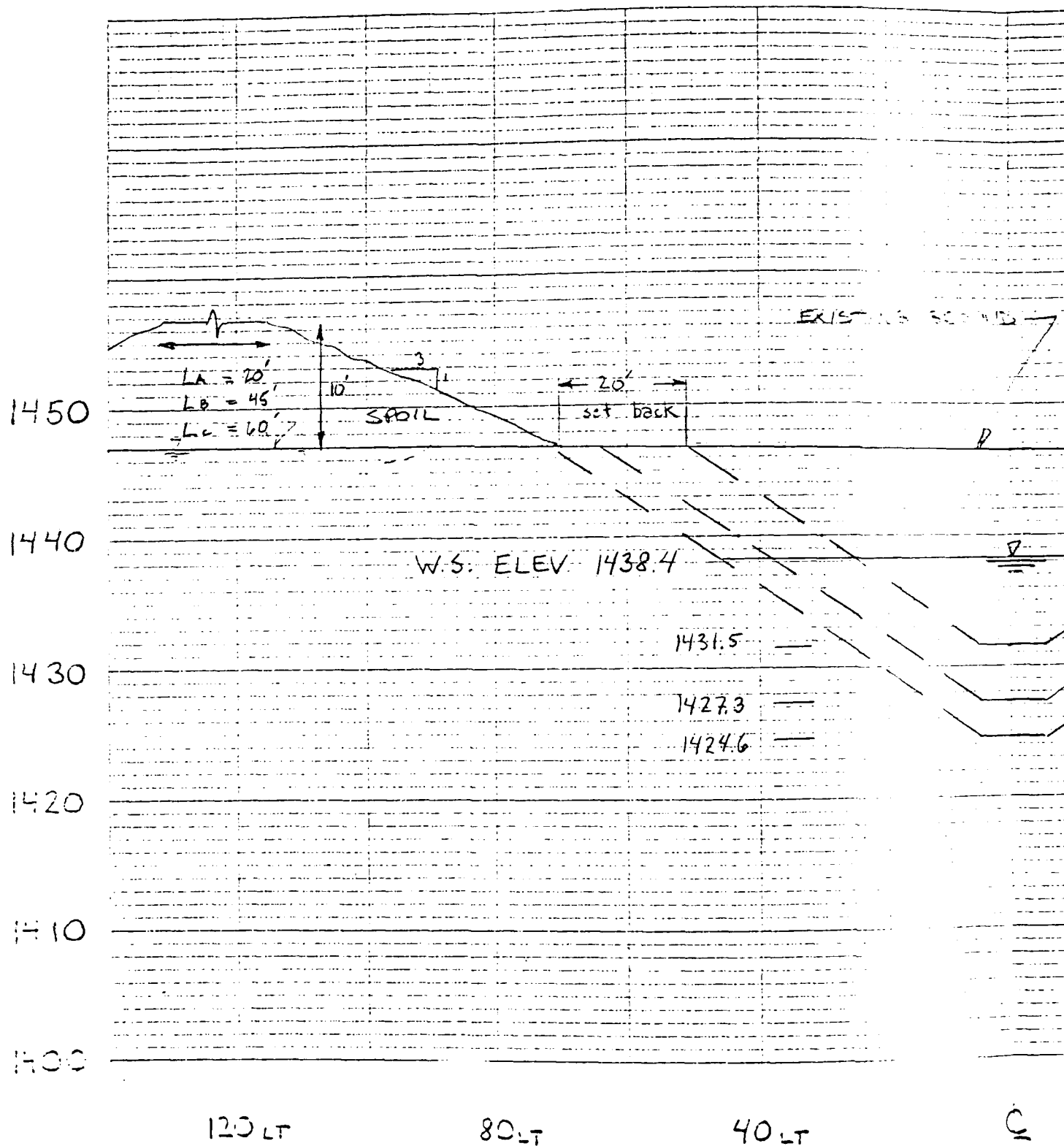
CROSS SECTION STA 275+00



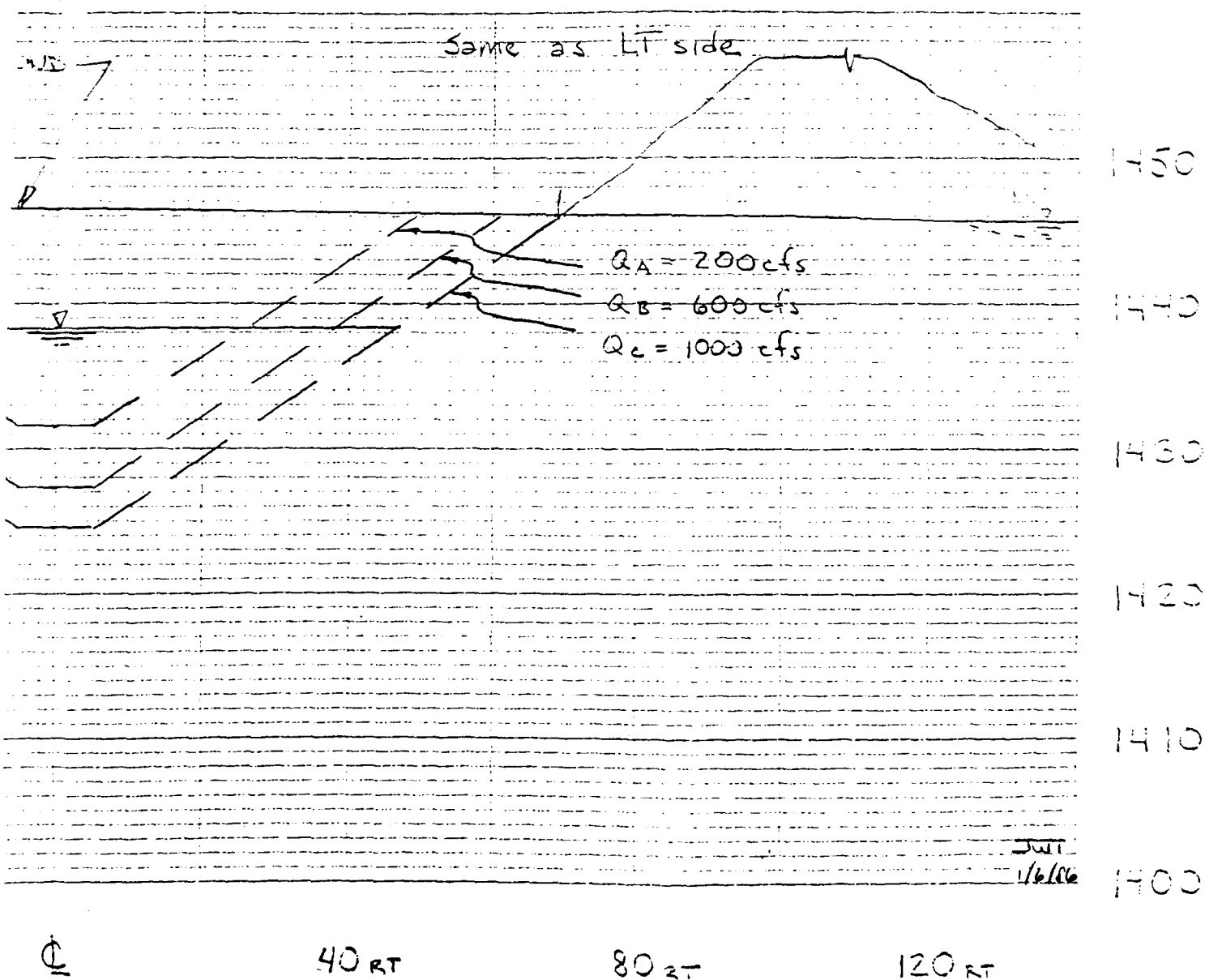


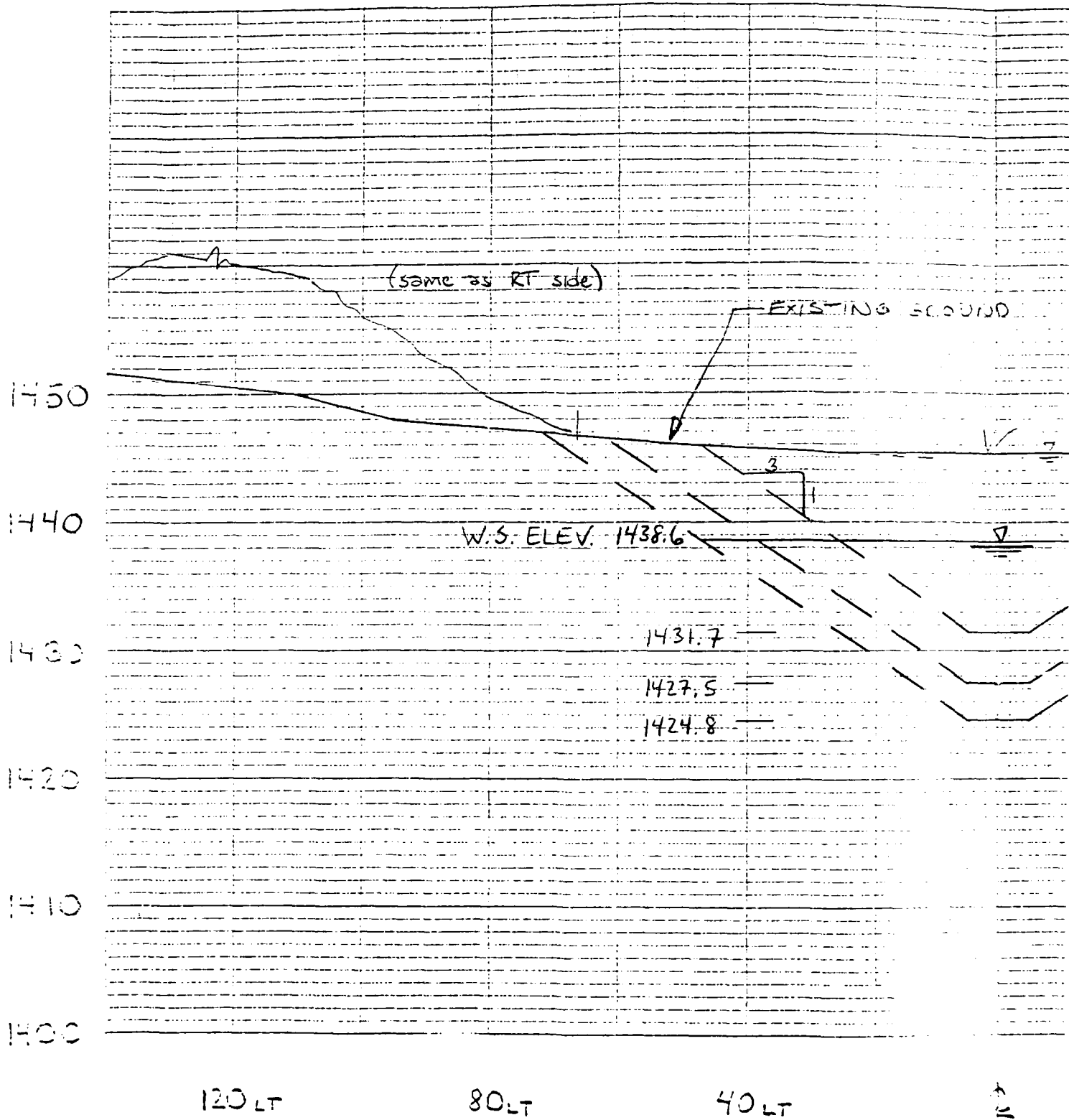
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 3A, B, & C CROSS SECTION STA 304+00



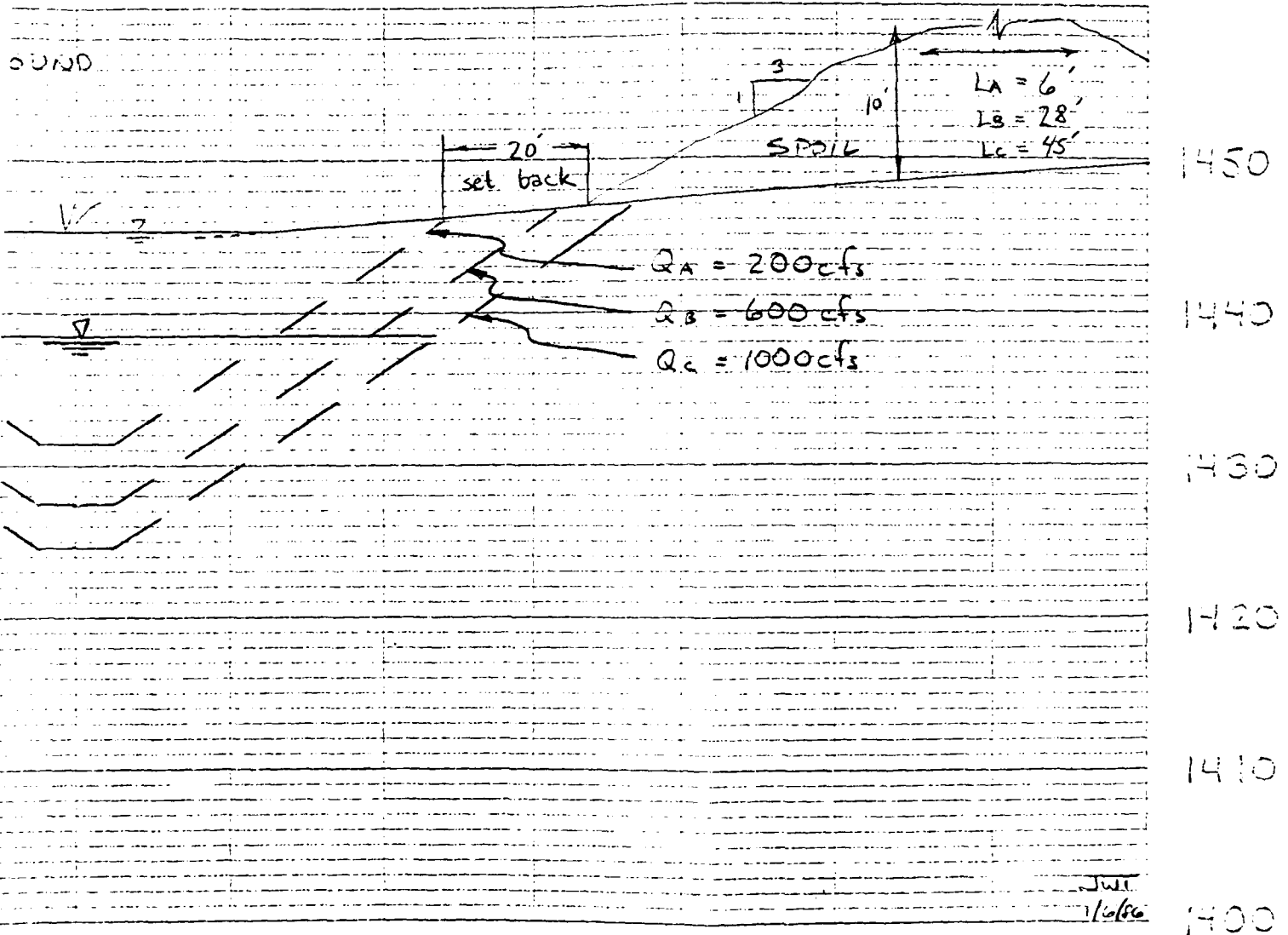


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 3A, B, & C  
CROSS SECTION STA 345-00



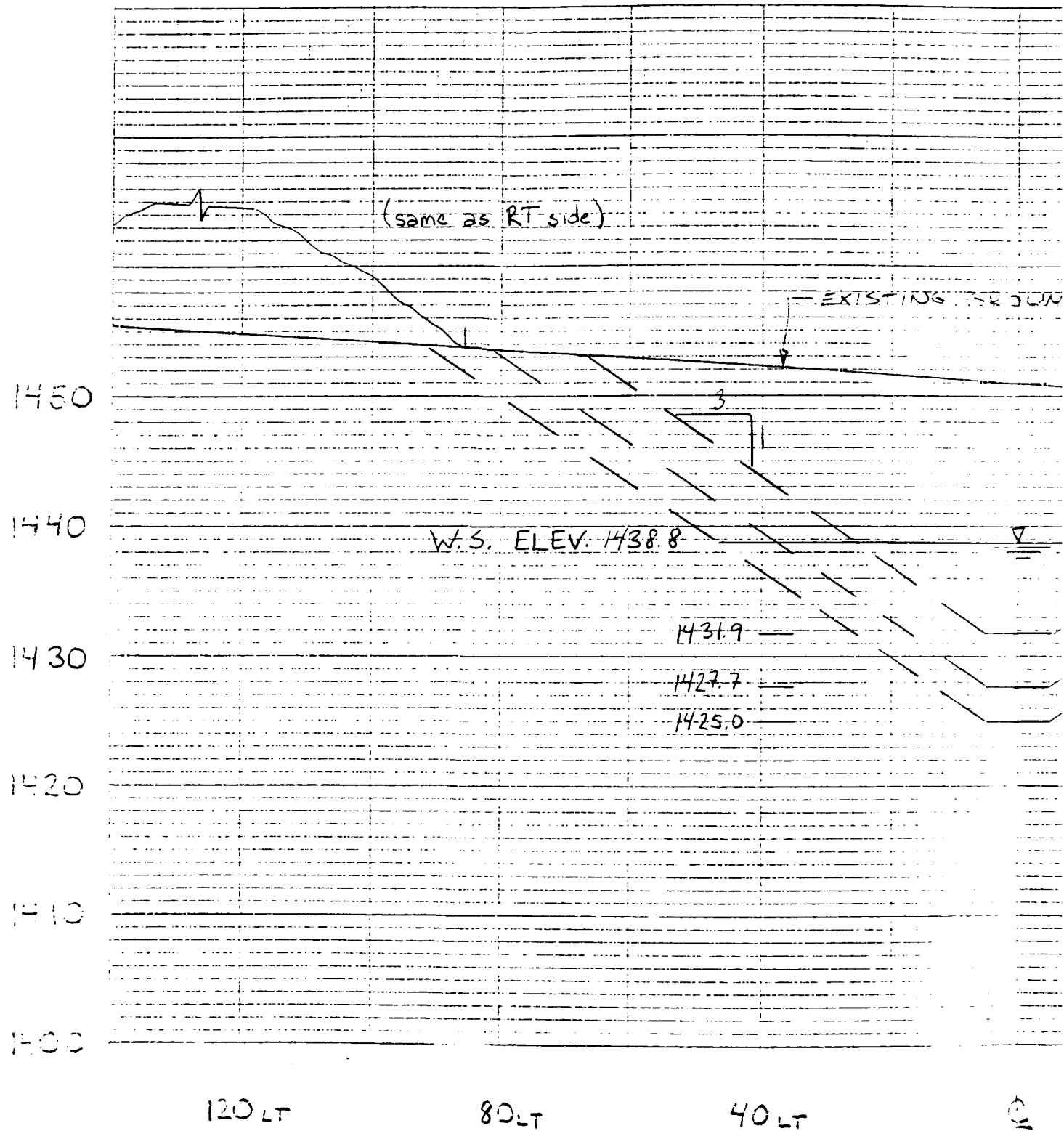


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 3A, B, & C  
CROSS SECTION STA 370+00

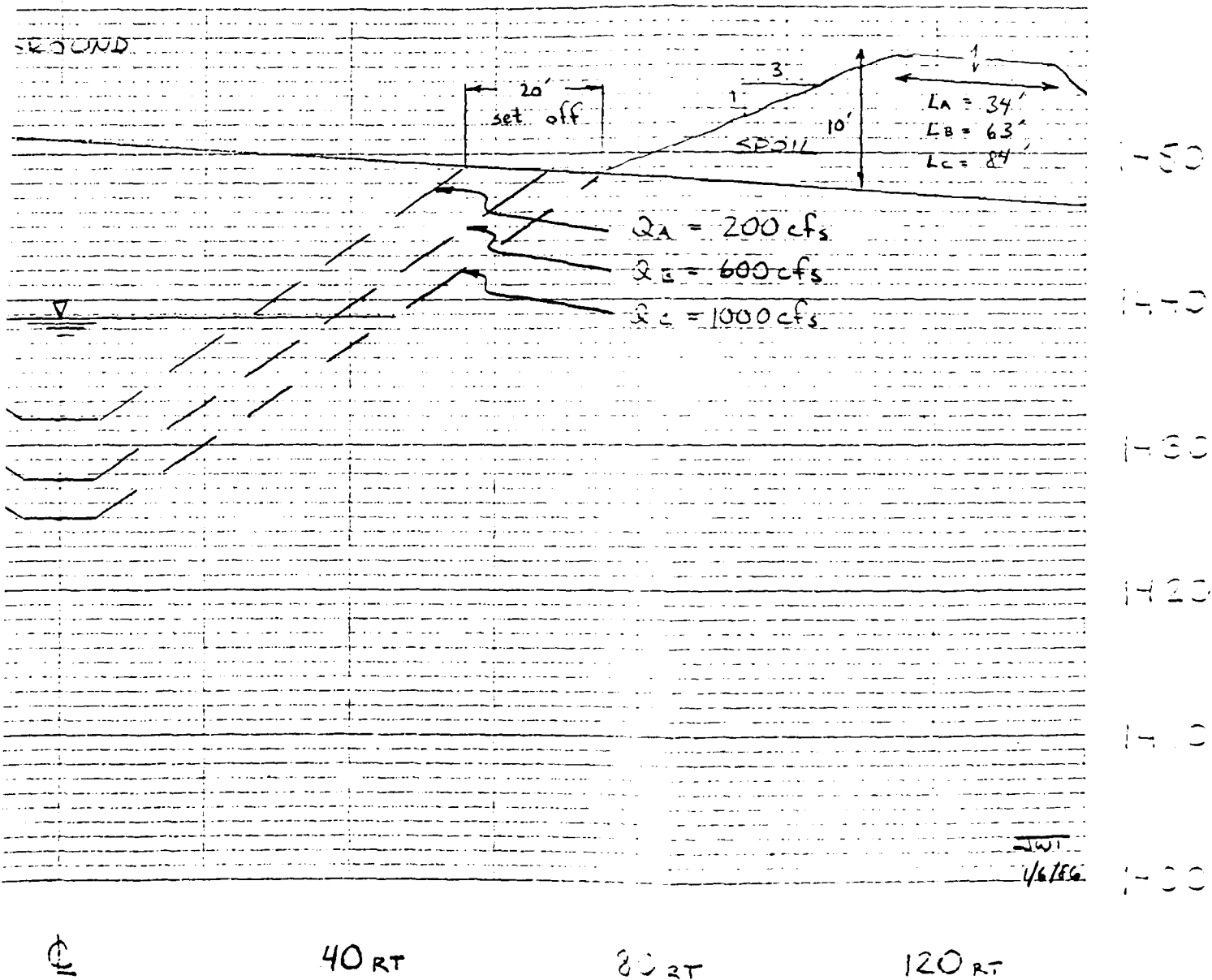


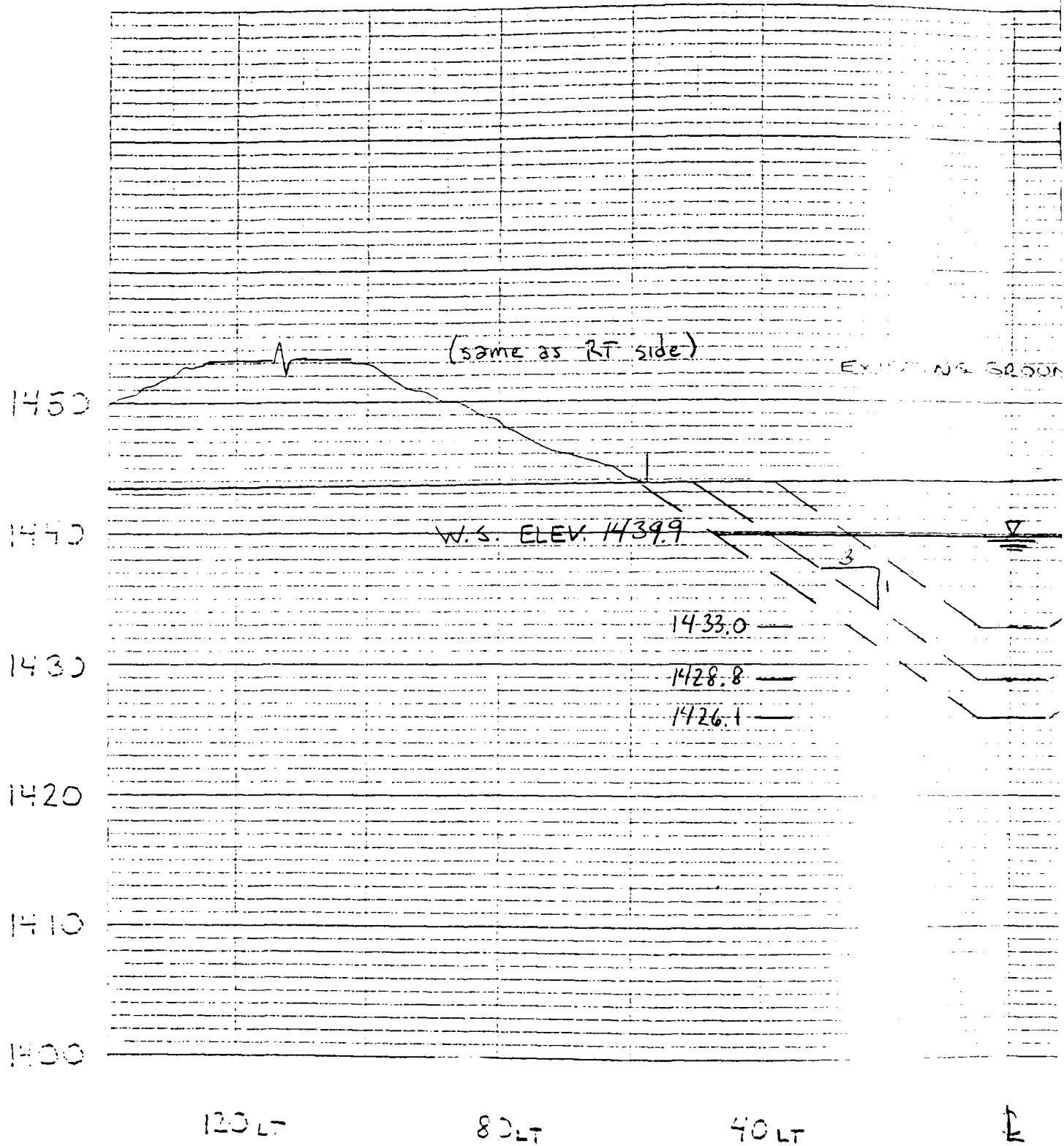
40 RT 30 RT 120 RT



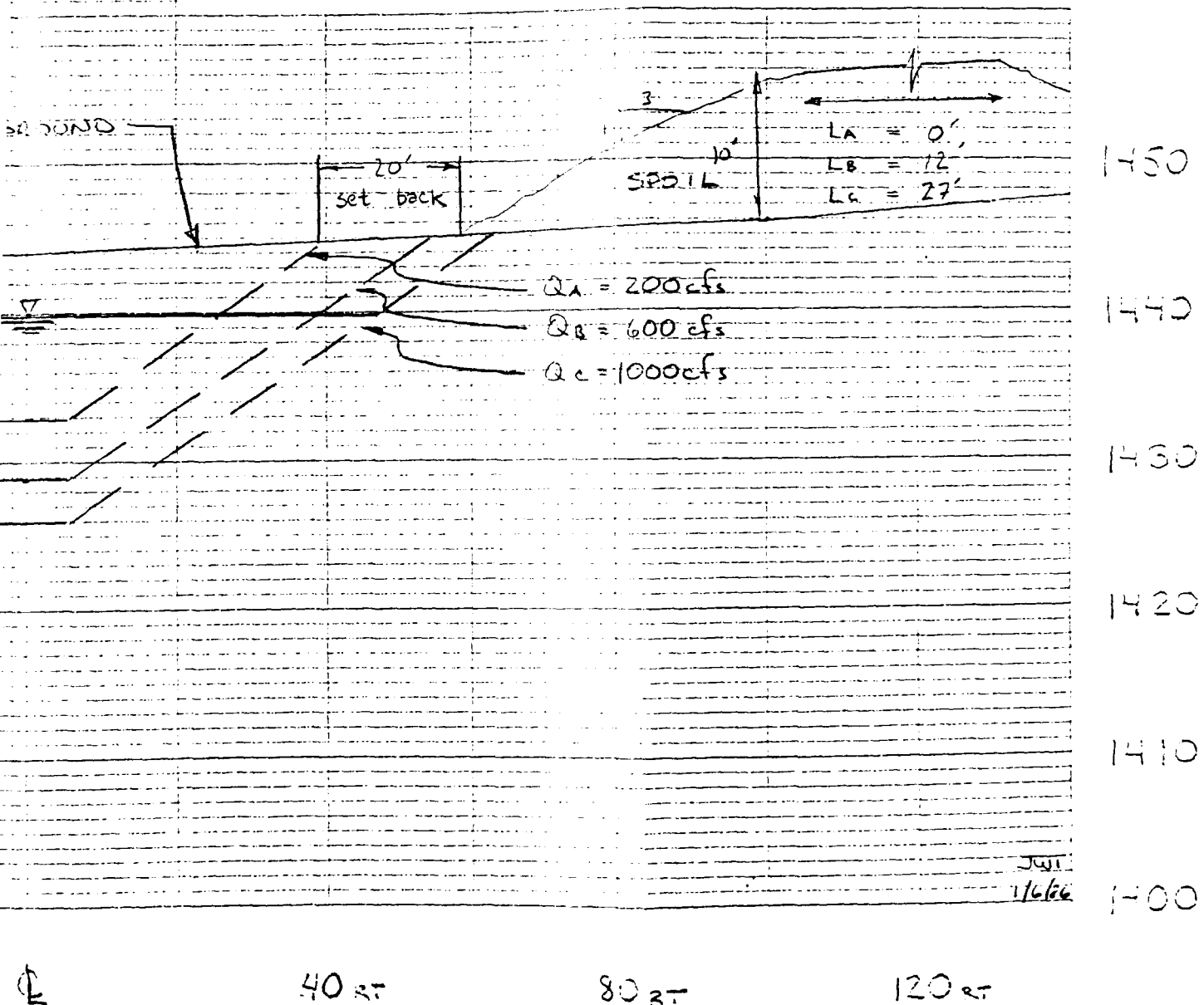


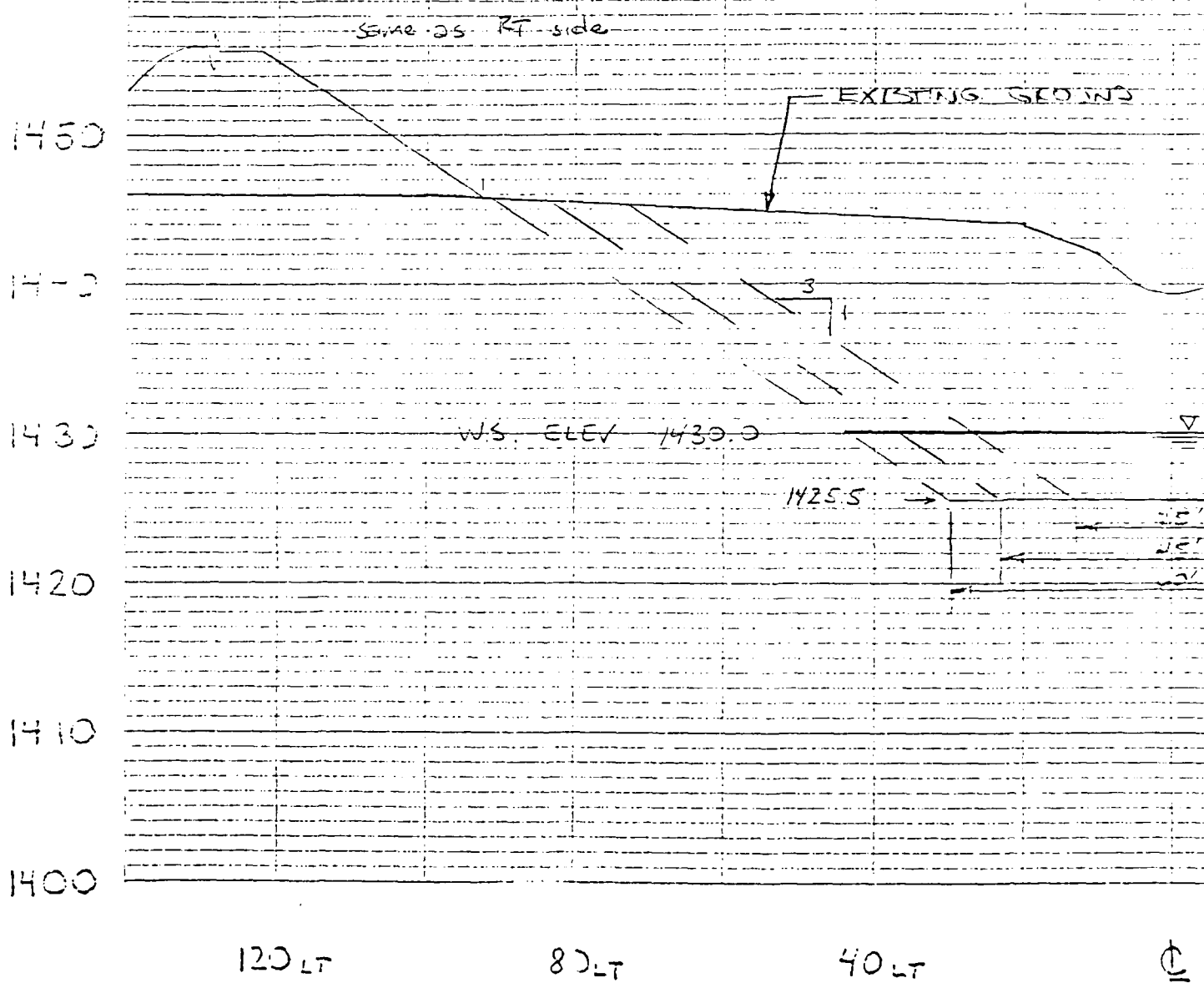
# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 3A, B, & C CROSS SECTION STA 398+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 3A, B, & C  
CROSS SECTION STA 485+00

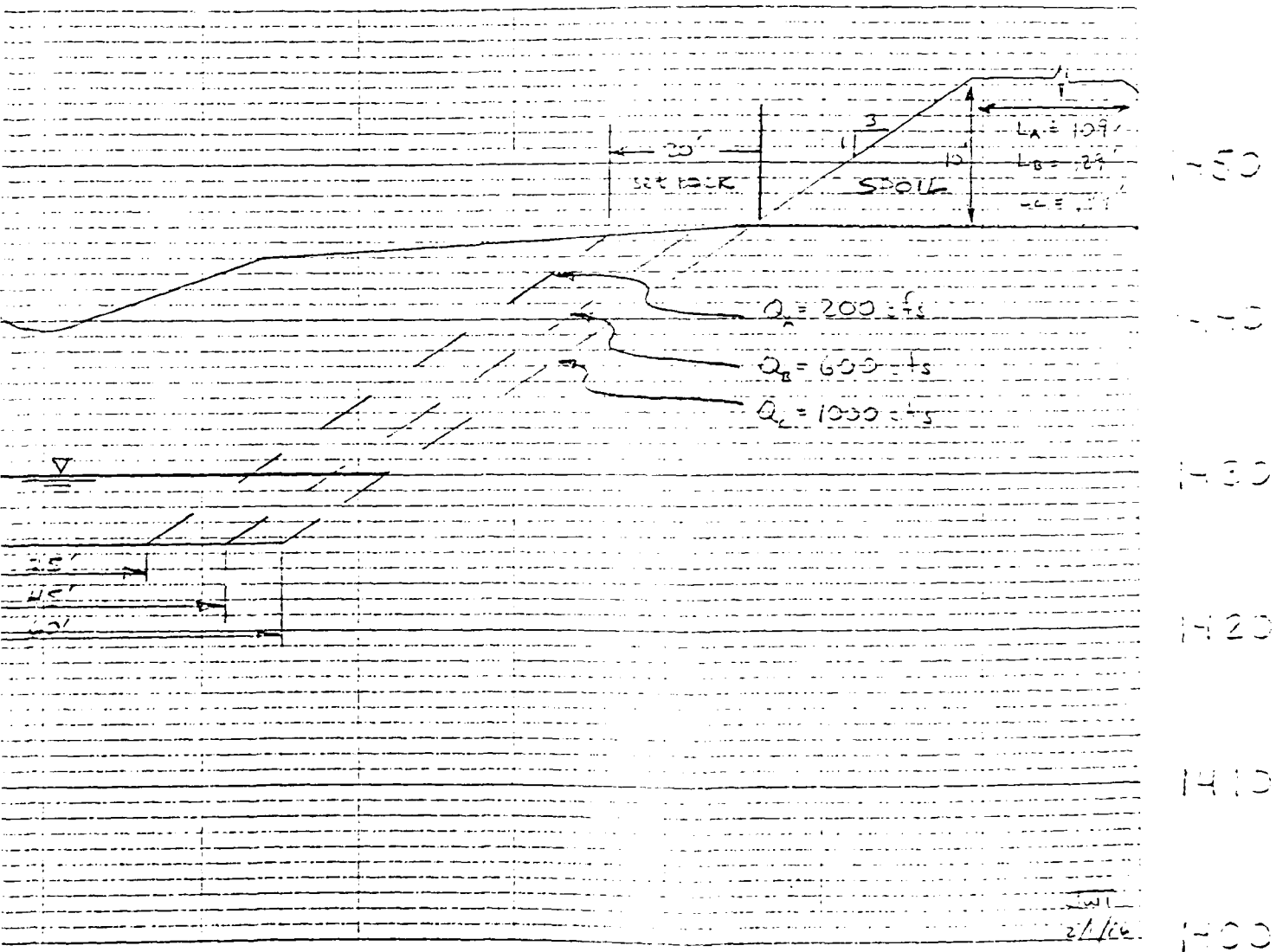




# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 3A, B, C

CROSS SECTION STA 514+00



①

40 RT

10 RT

100 RT

1450

1440

1430

1420

1410

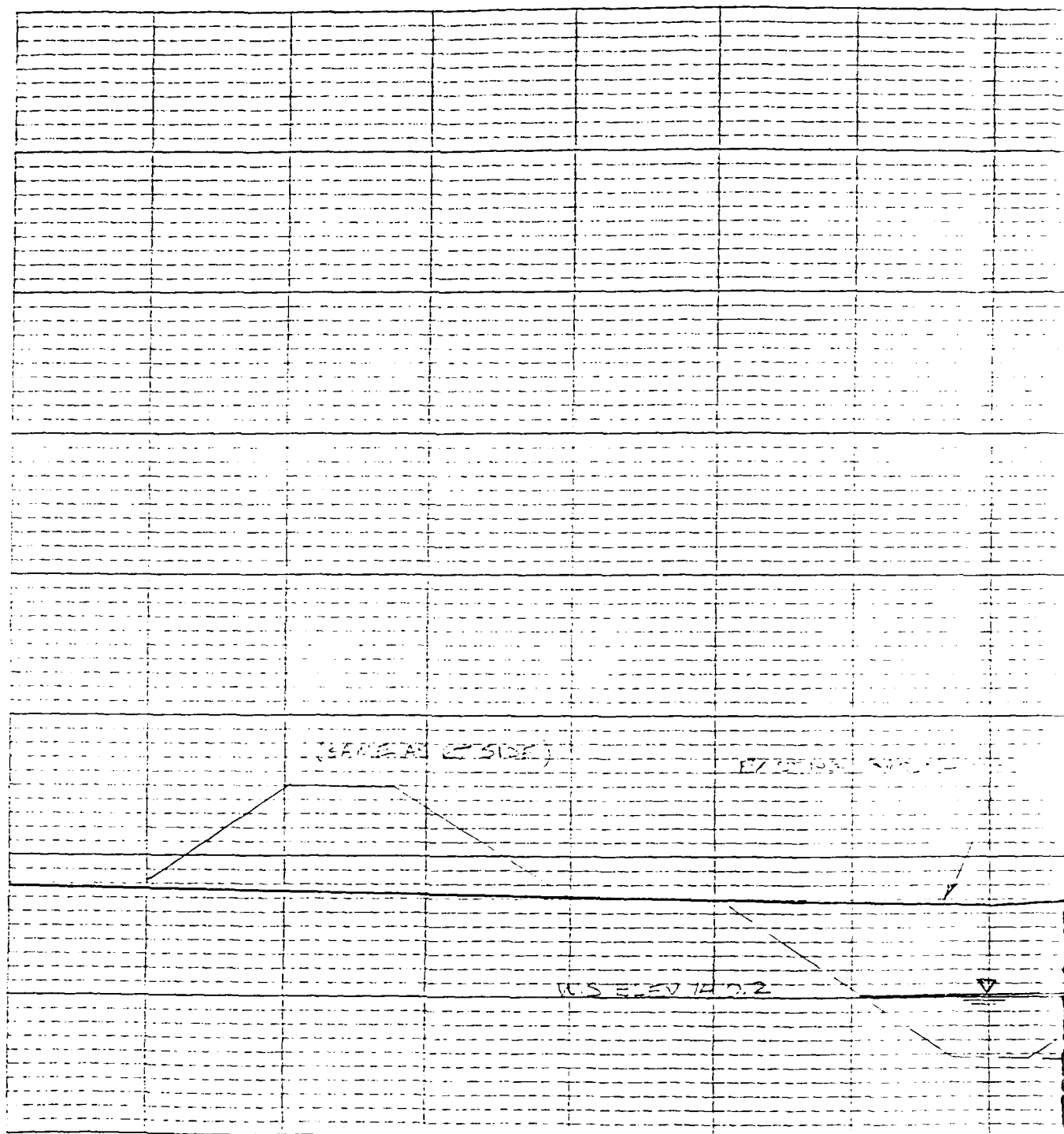
1400

120<sub>LT</sub>

80<sub>LT</sub>

40<sub>LT</sub>

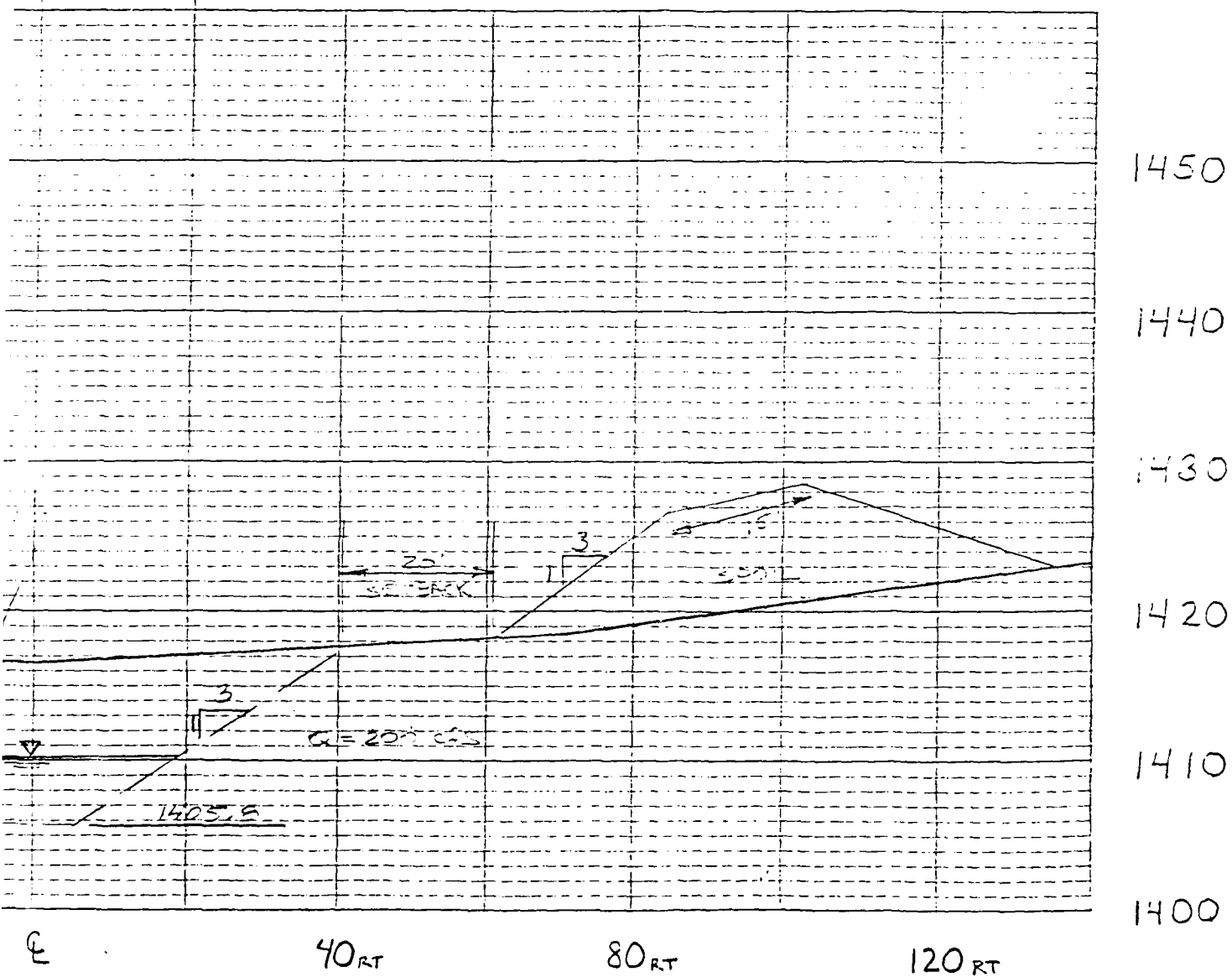
0



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE 4H, L

CROSS SECTION STA 25+00





1450

(same as RT side)

EX. 5110179

1440

1430

W.S. ELEV. 1429.7

1424.1

1420

1410

1400

120<sub>LT</sub>

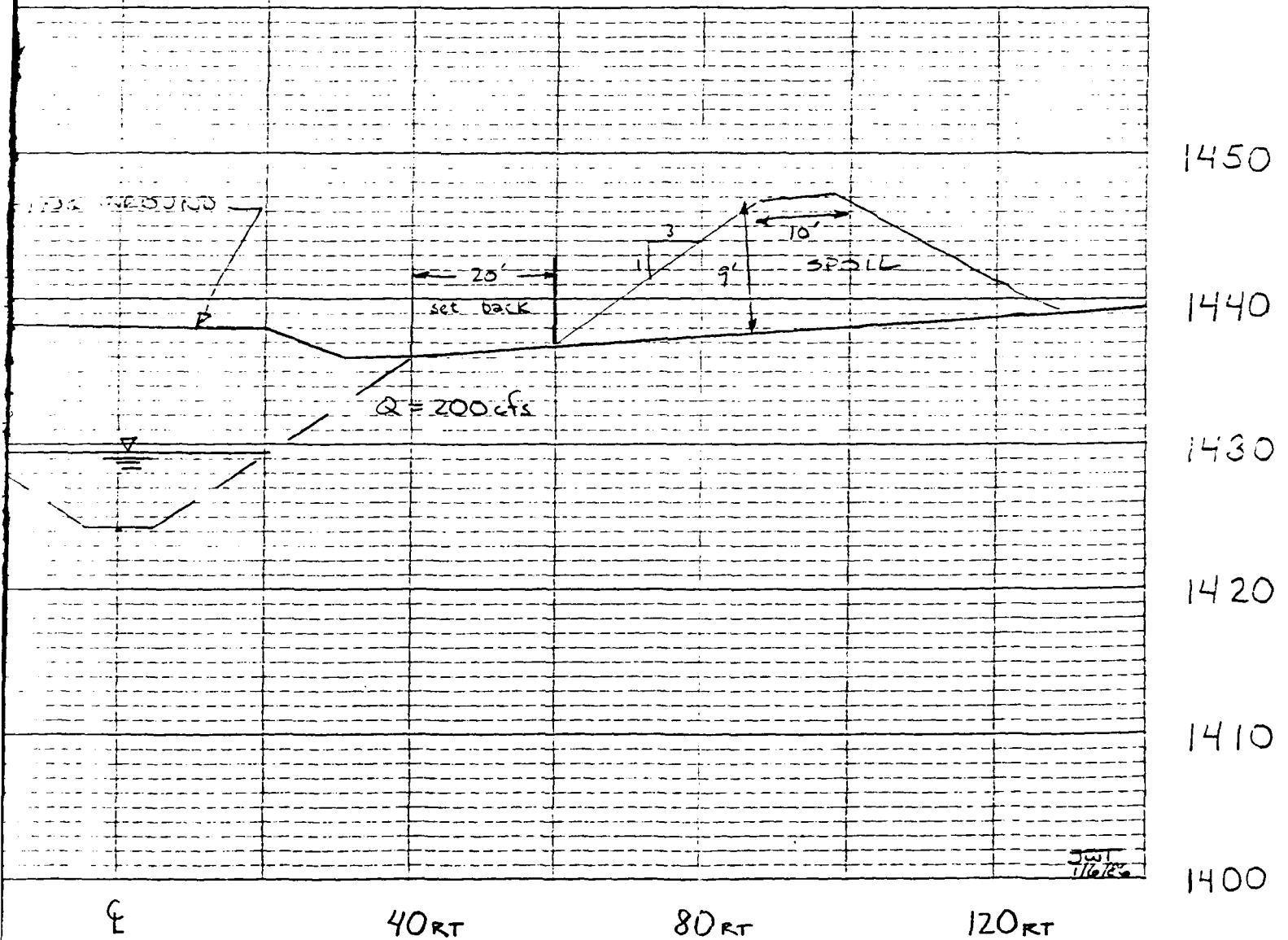
80<sub>LT</sub>

40<sub>LT</sub>

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 4H, L

CROSS SECTION STA 70+00



1450

1440

1430

1420

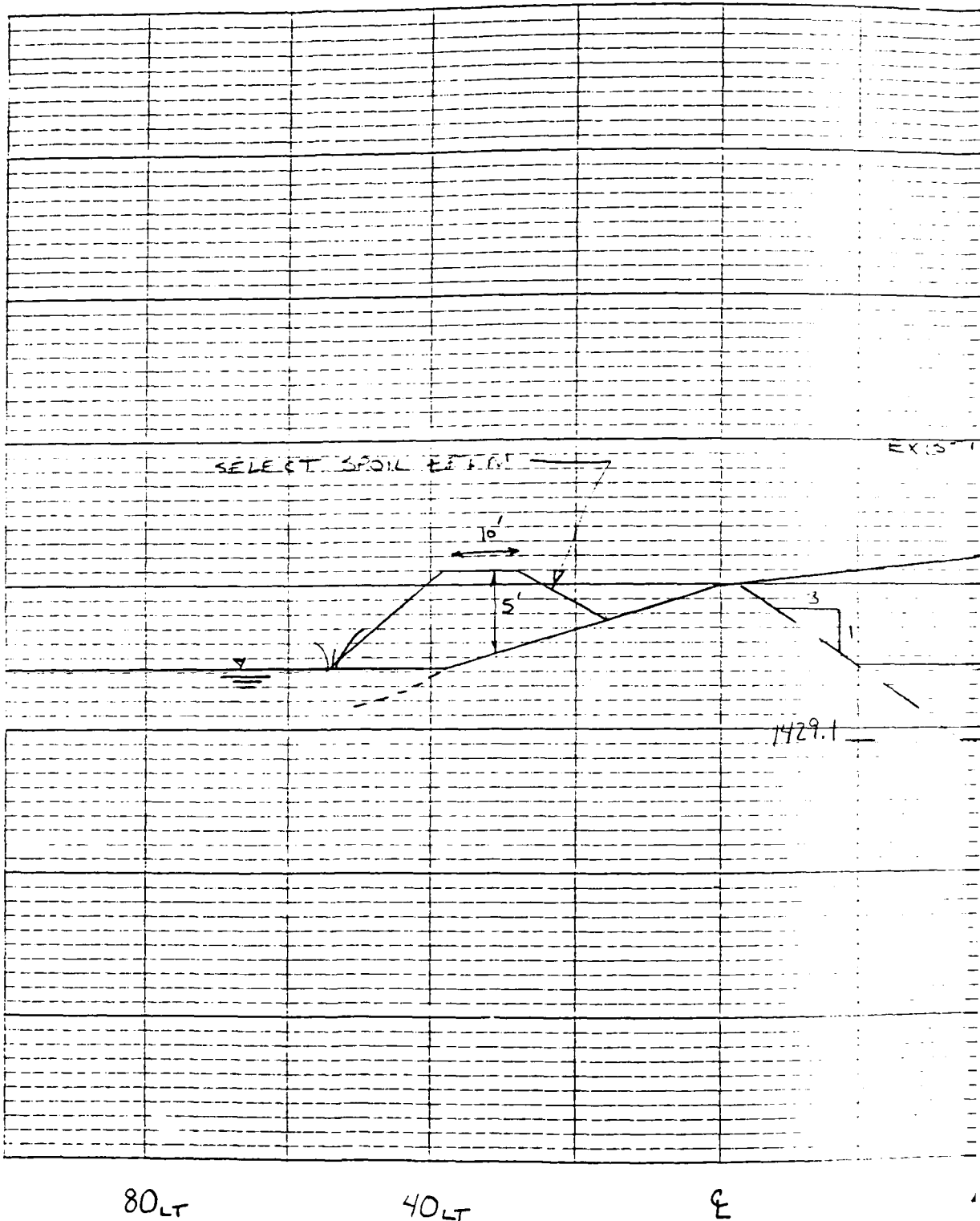
1410

1400

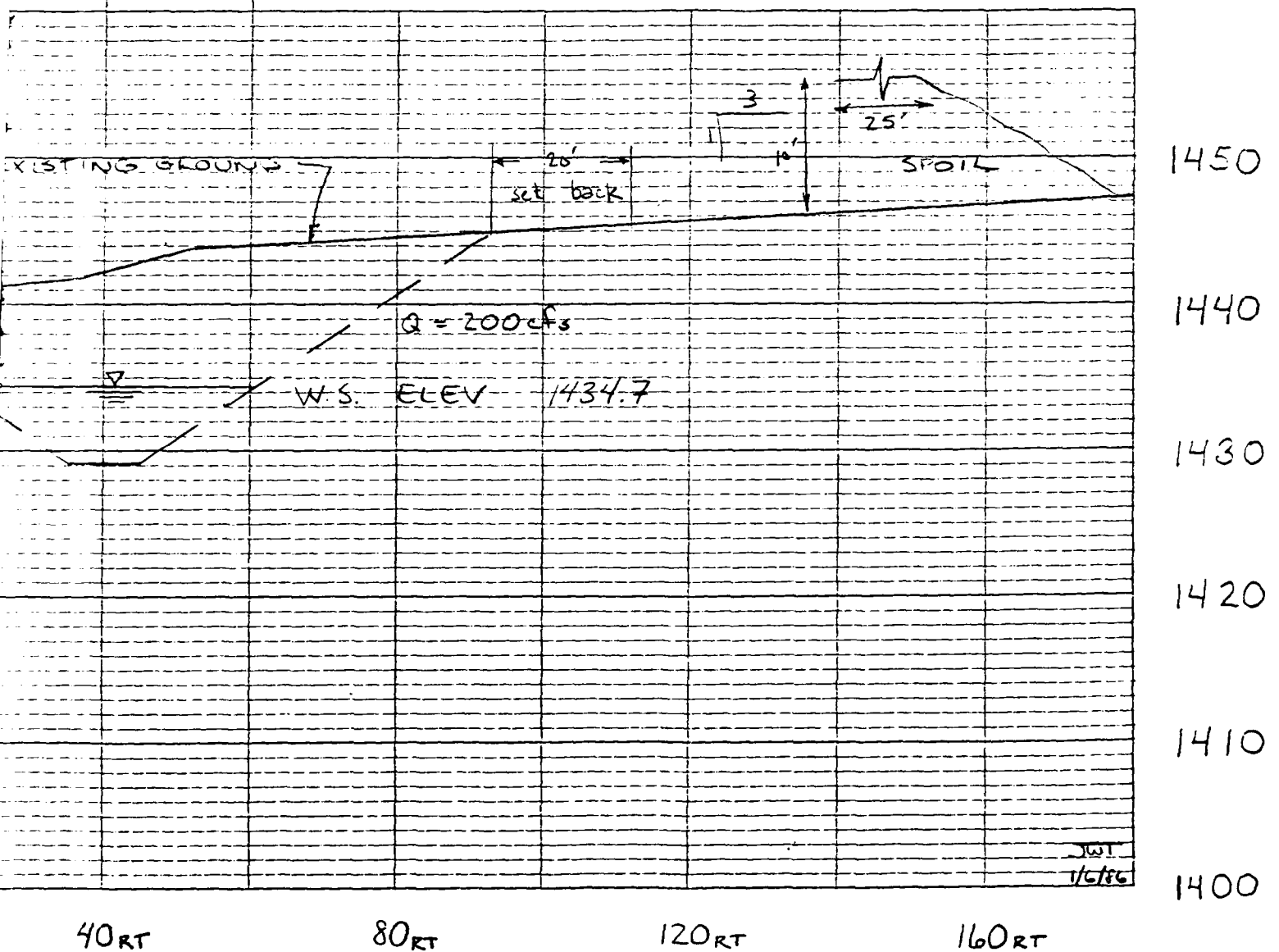
80<sub>LT</sub>

40<sub>LT</sub>

2



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H, L  
CROSS SECTION STA 120+00



1450

1440

1430

1420

1410

1400

120 LT

80 LT

40 LT

0

(same as RT side)

W.S. ELEV. 1435.7

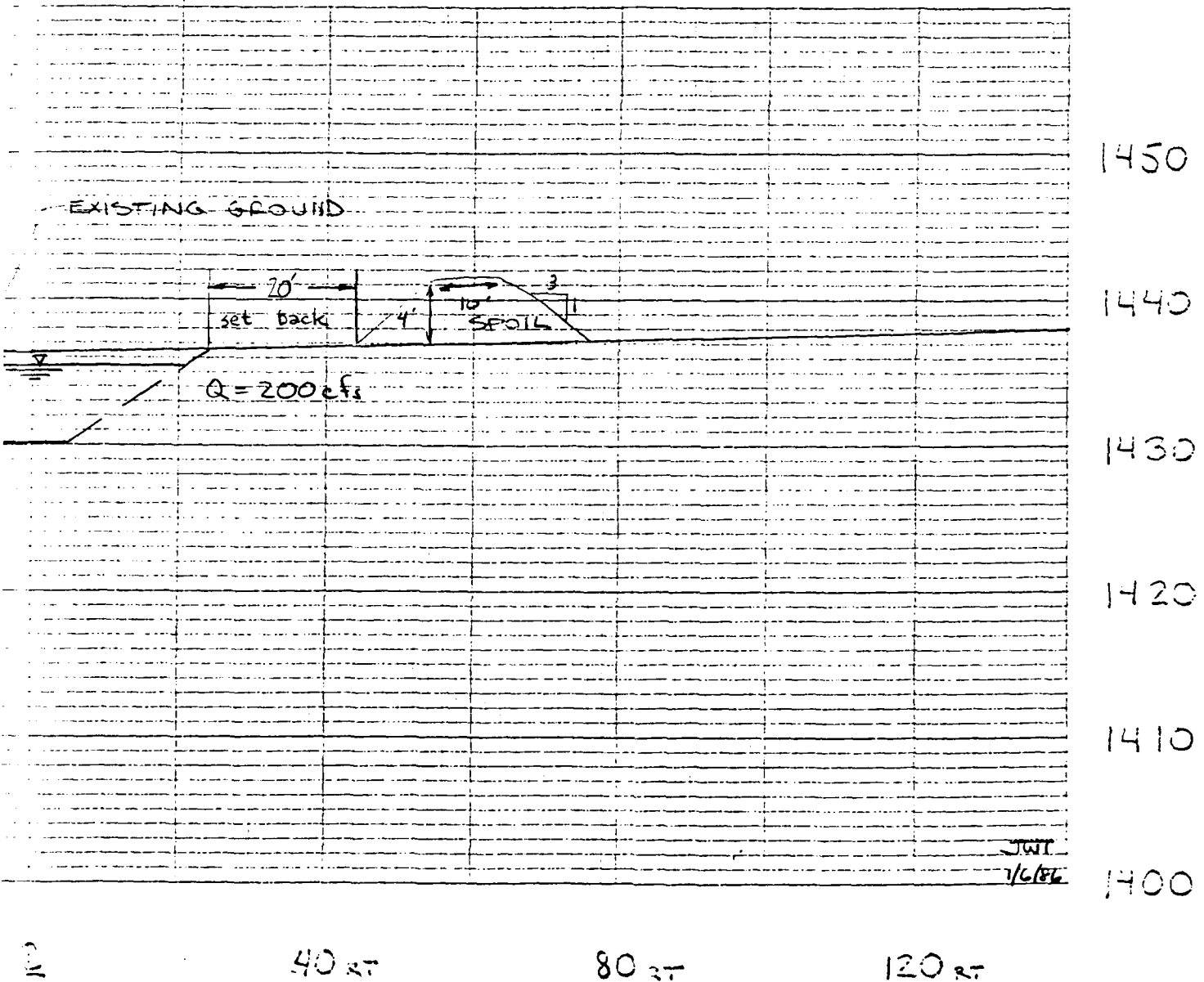
1430.1

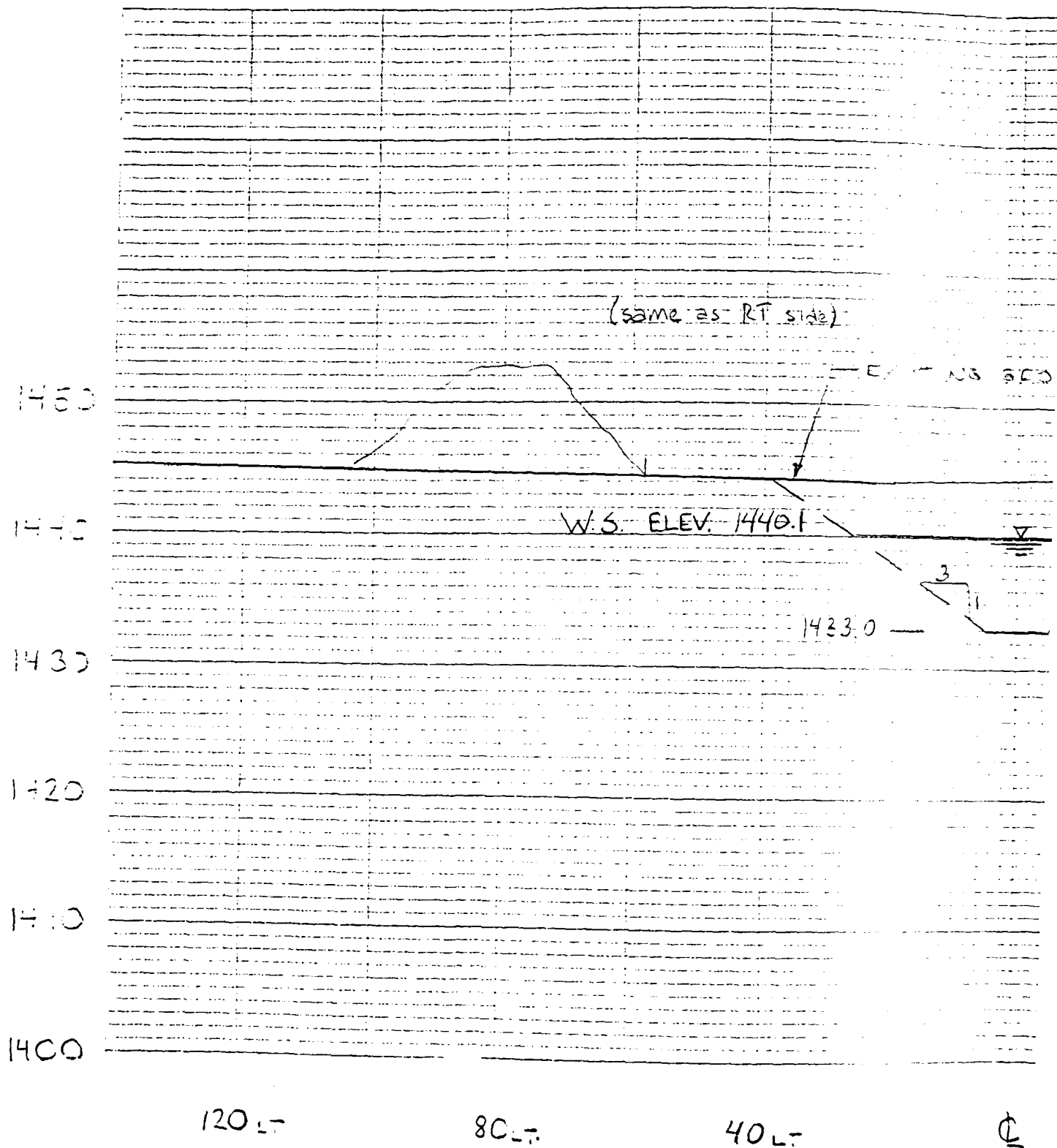
3

1

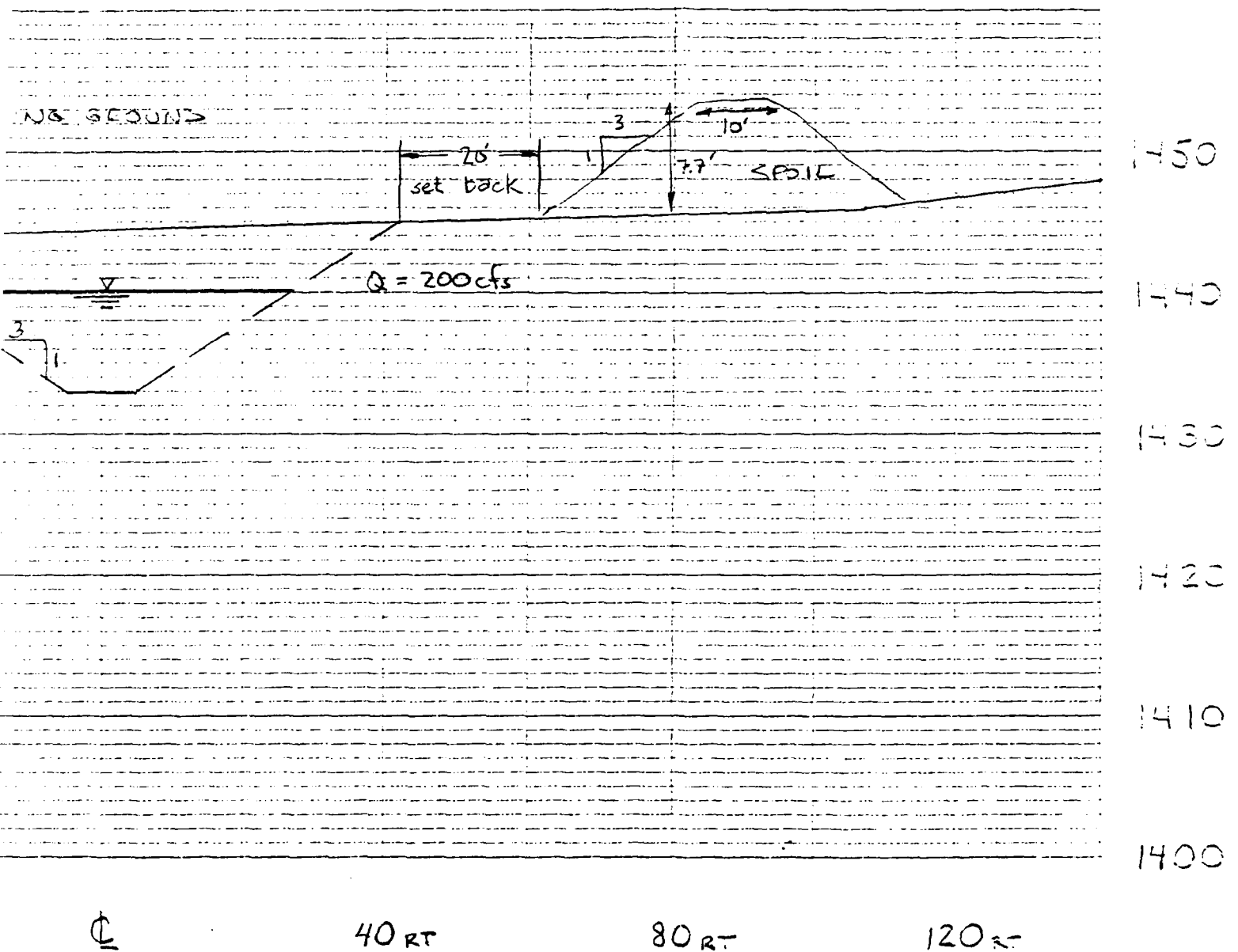
E

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 4H,L CROSS SECTION STA 170+00

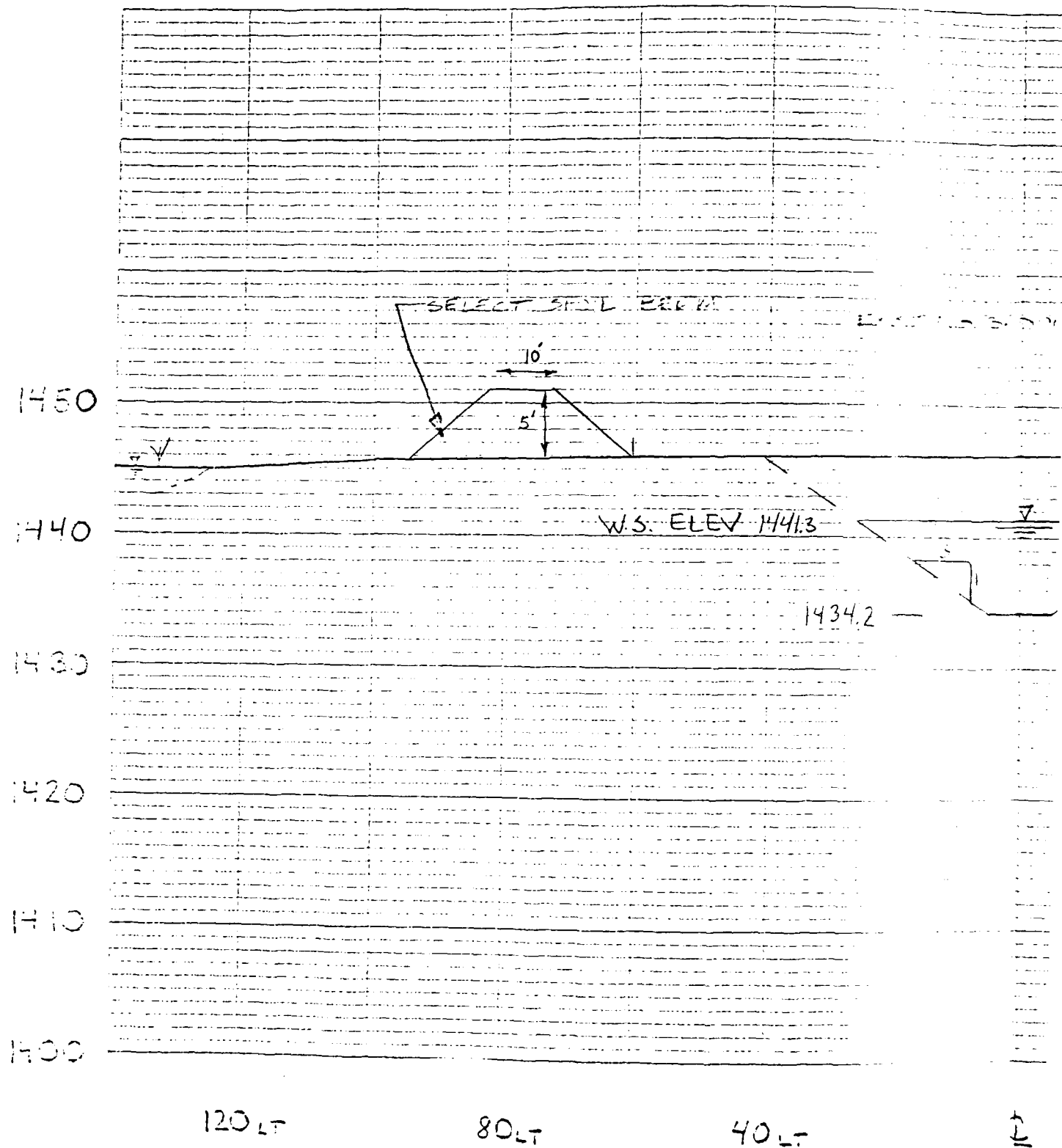




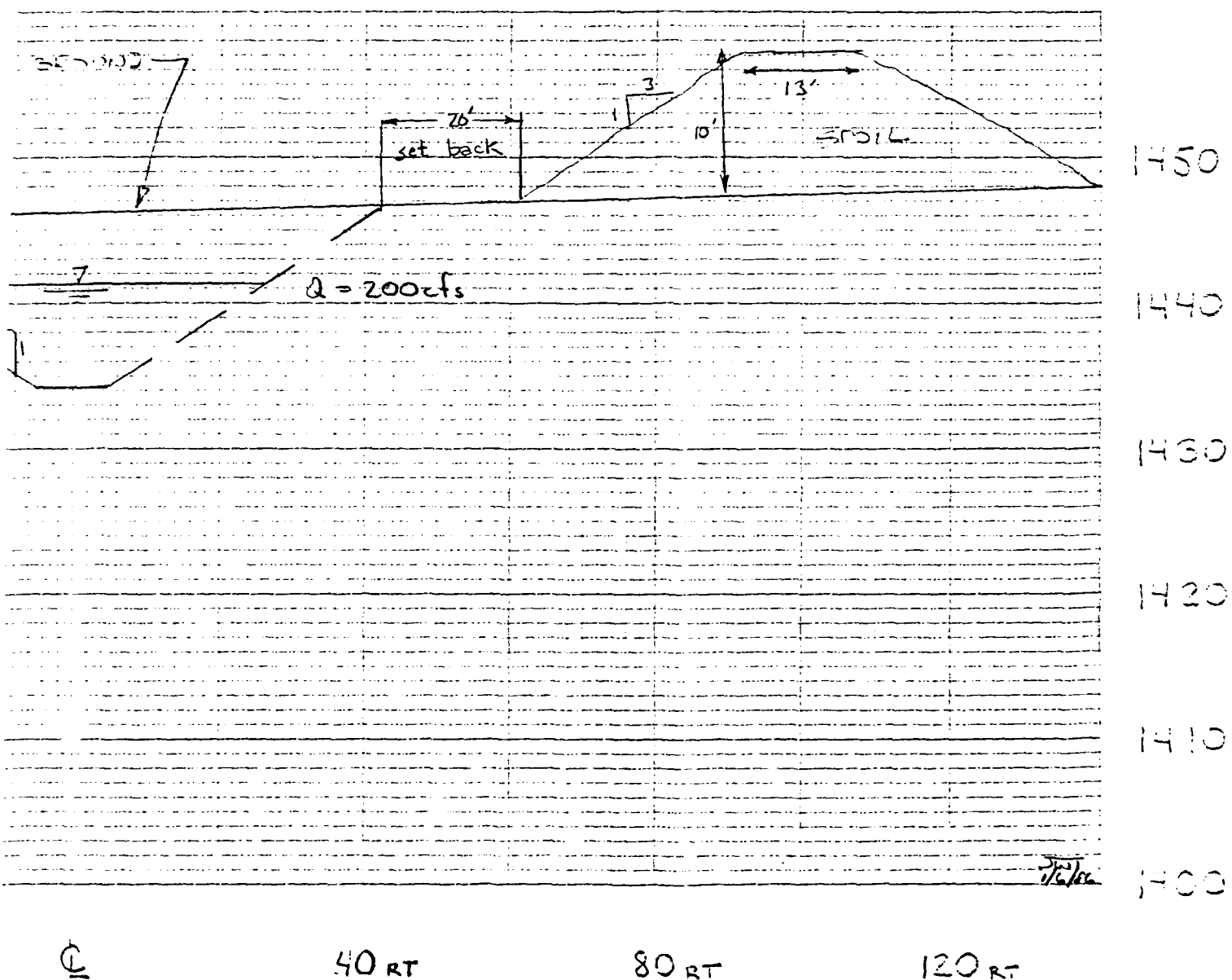
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H, L  
CROSS SECTION: STA 210+00

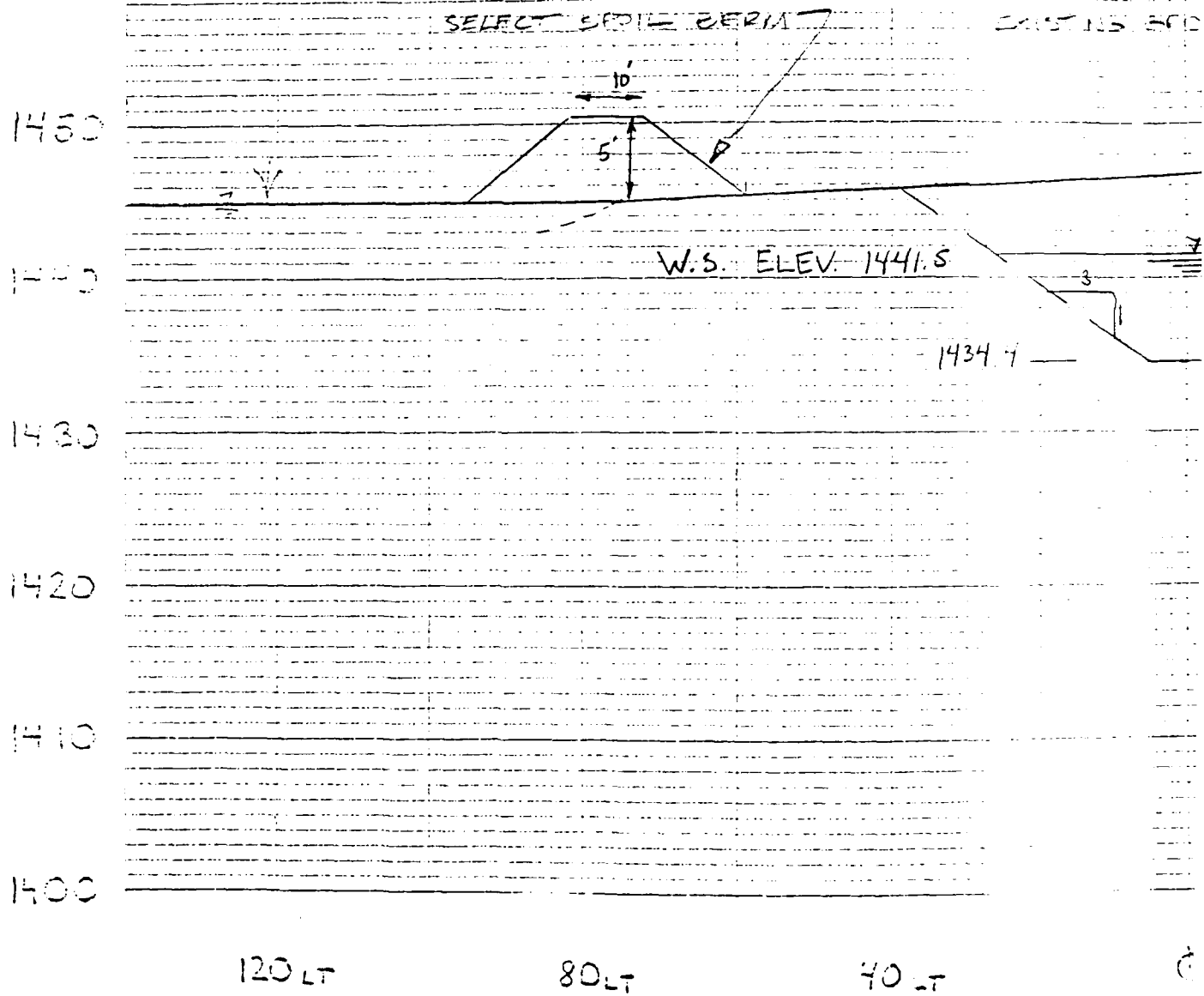




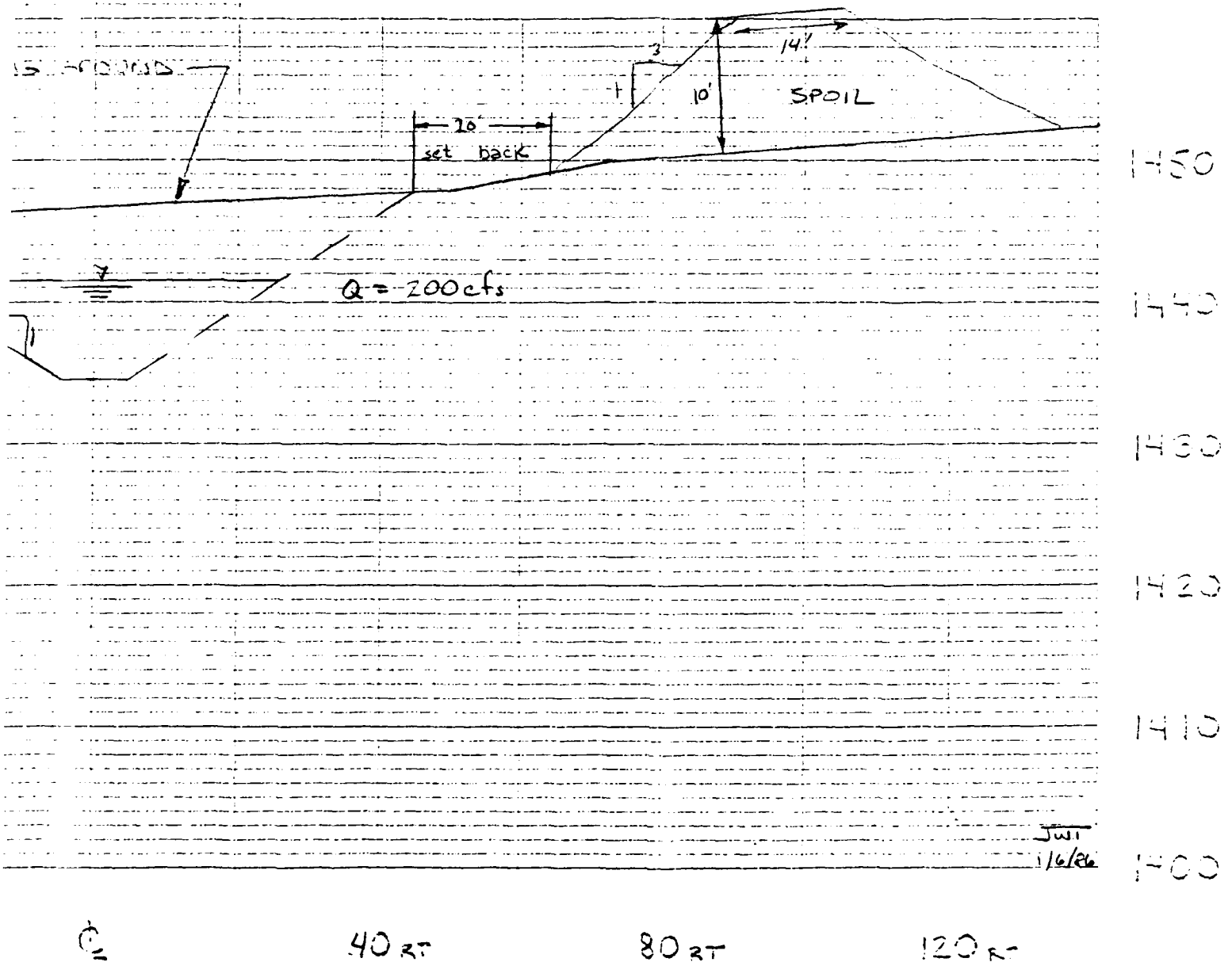


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H, L  
CROSS SECTION STA 244+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H, L  
CROSS SECTION STA 275+00



1450

1440

1430

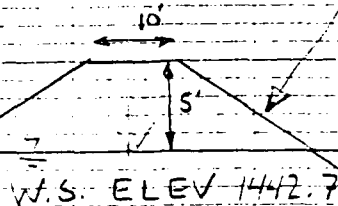
1420

1410

1400

SELECT SED. ELEV.

EXISTING



1435.6

120 LT

80 LT

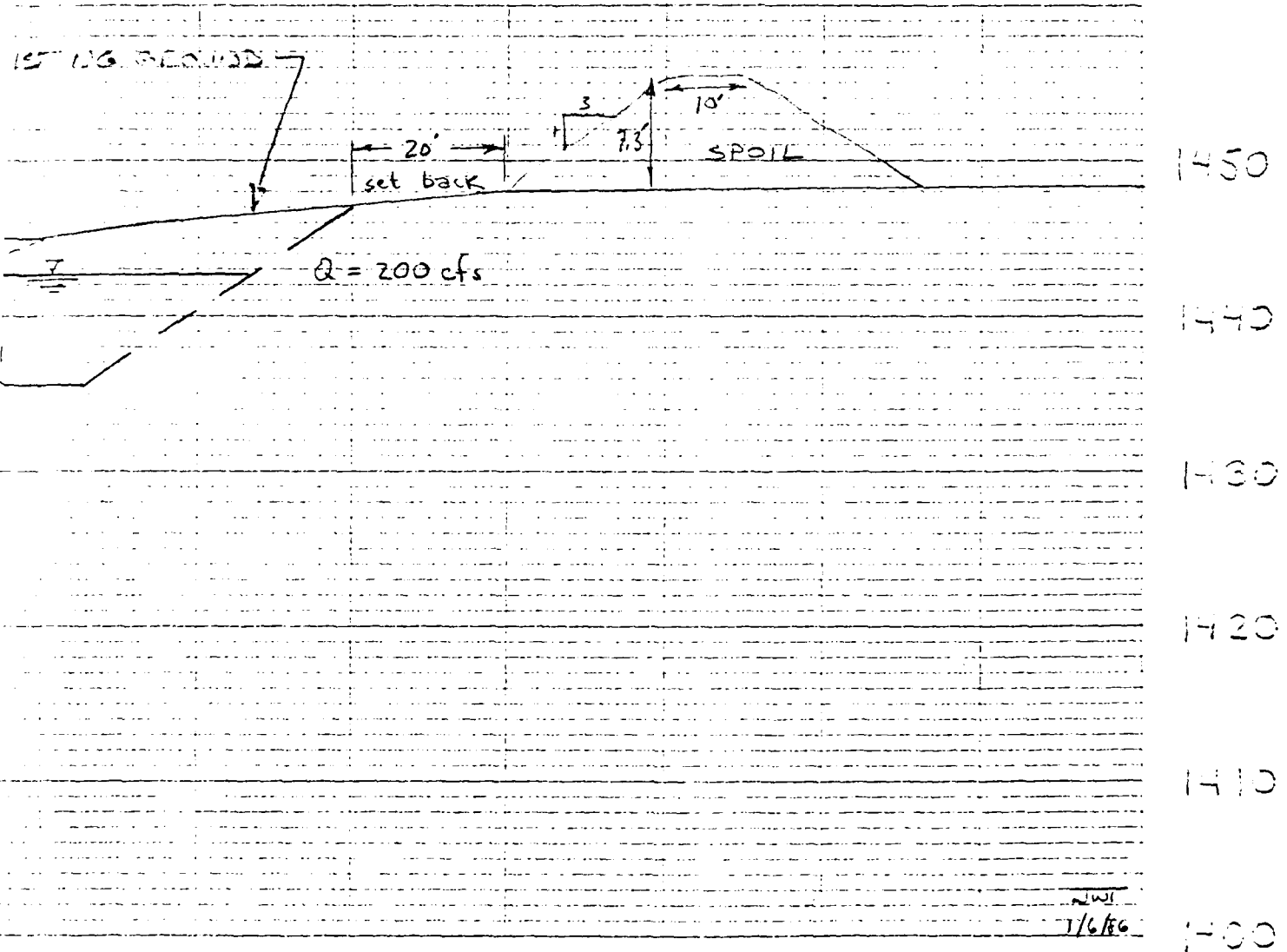
40 LT

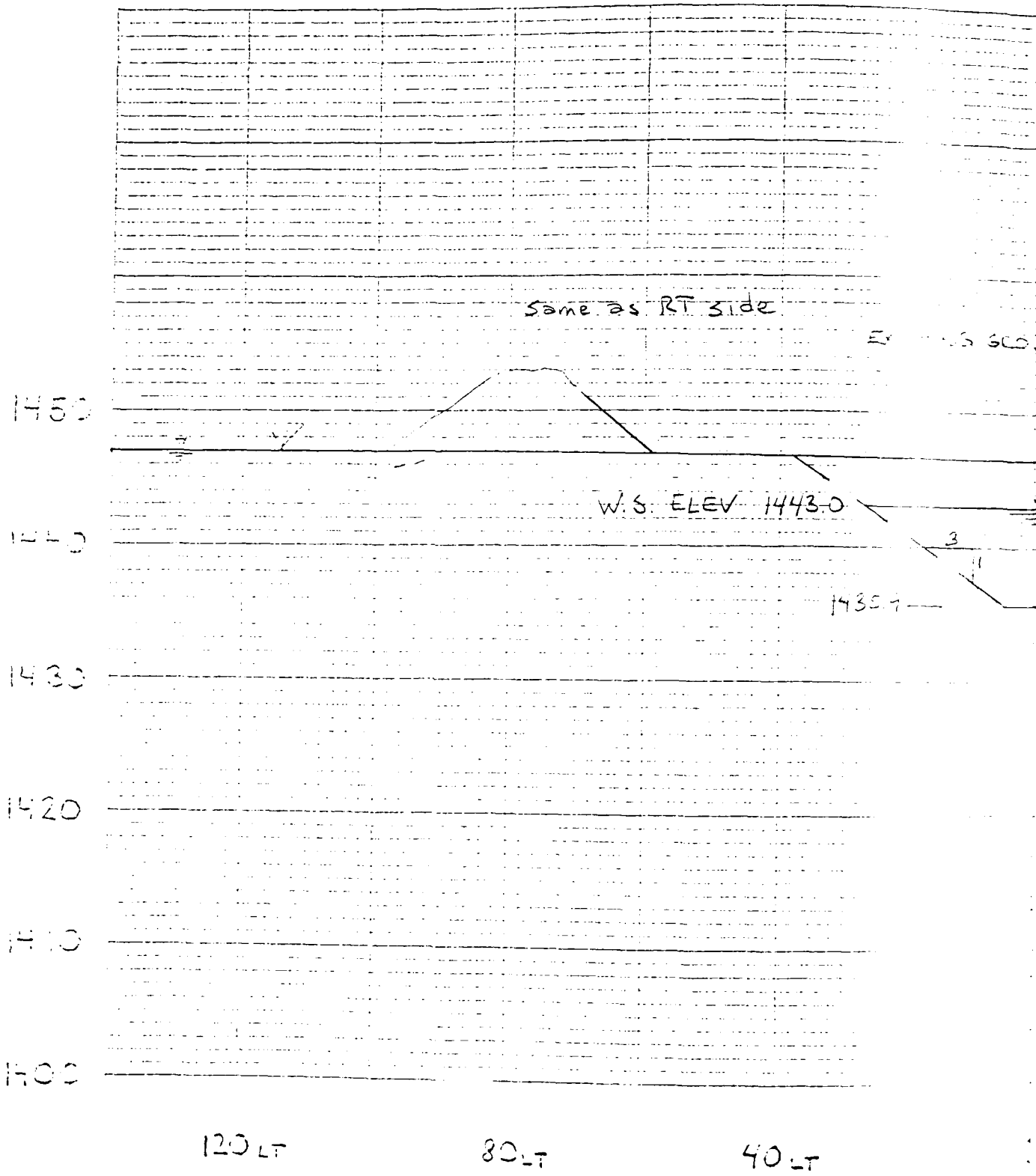
1

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

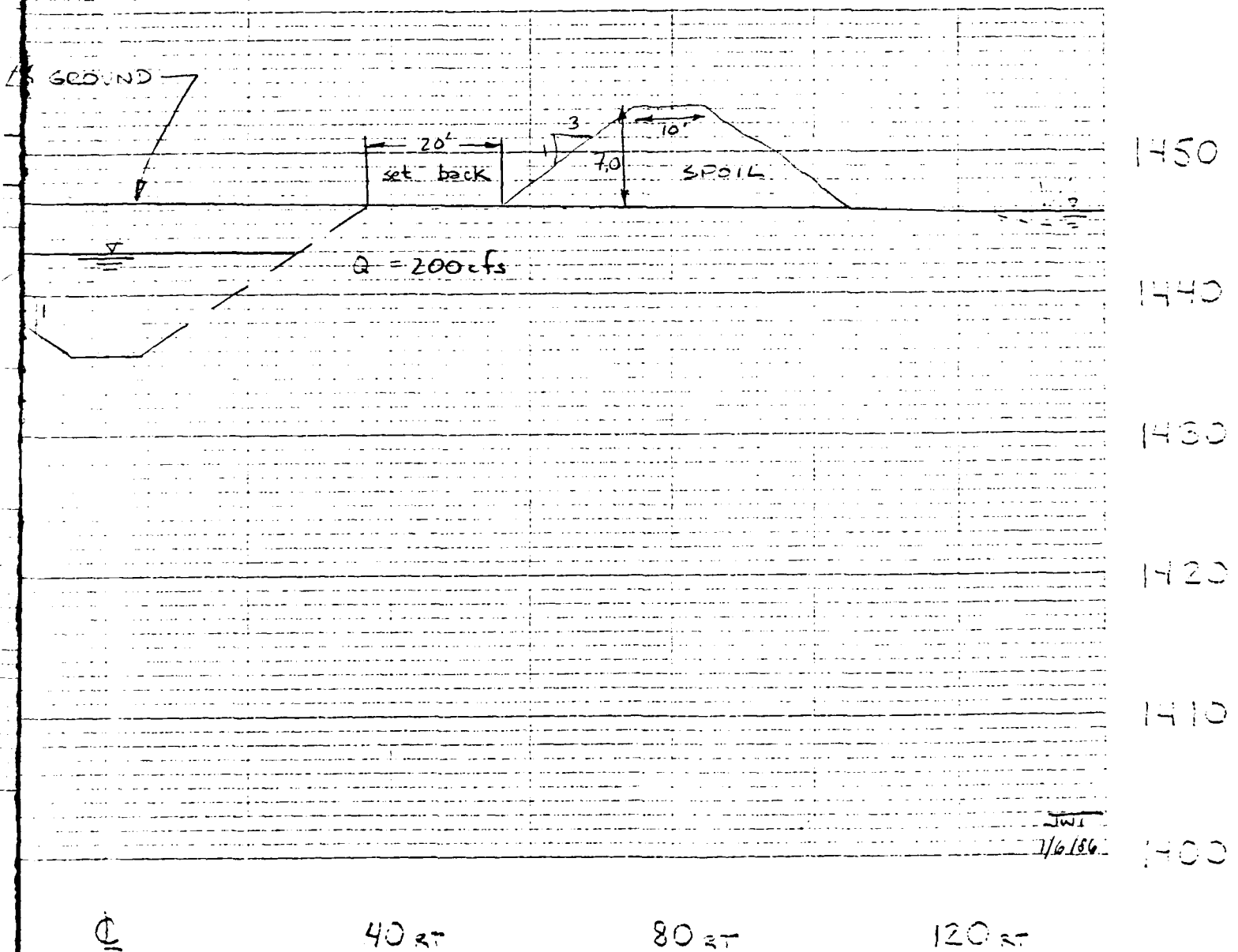
CASE 4H, L

CROSS SECTION STA 304+00

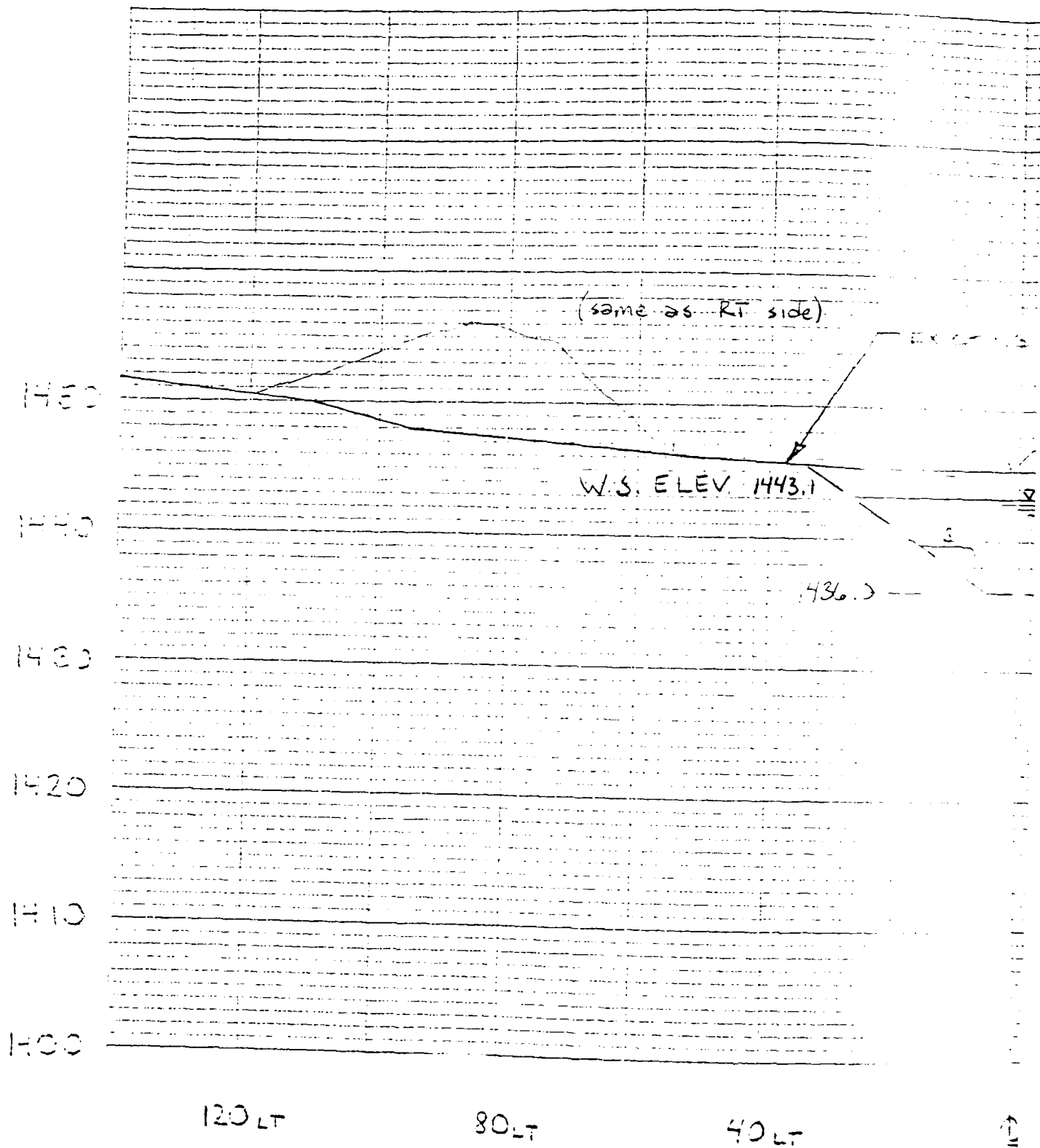




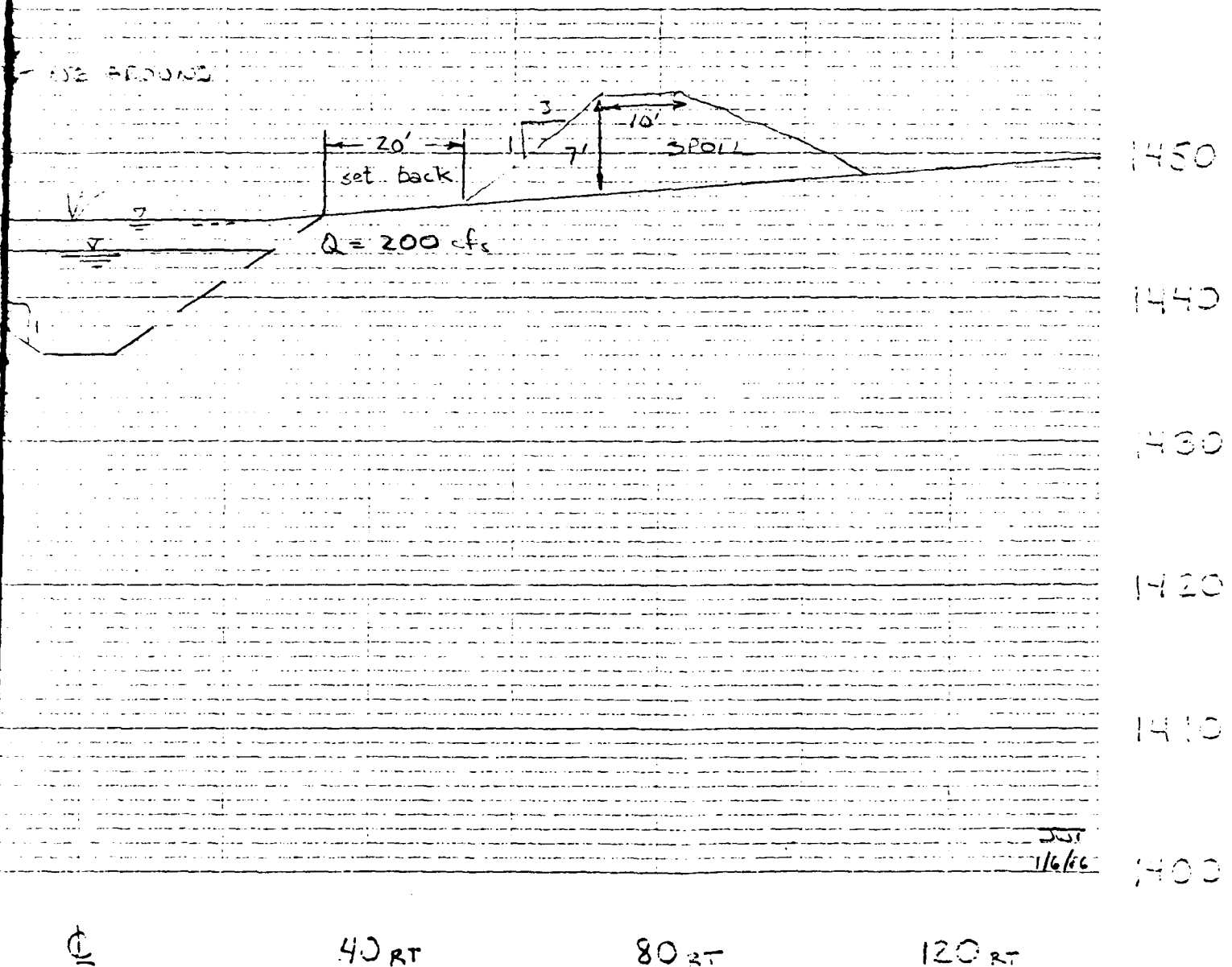
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H.L  
CROSS SECTION STA 345+00







CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 44.L  
CROSS SECTION STA 870+00



1450

1440

1430

1420

1410

1400

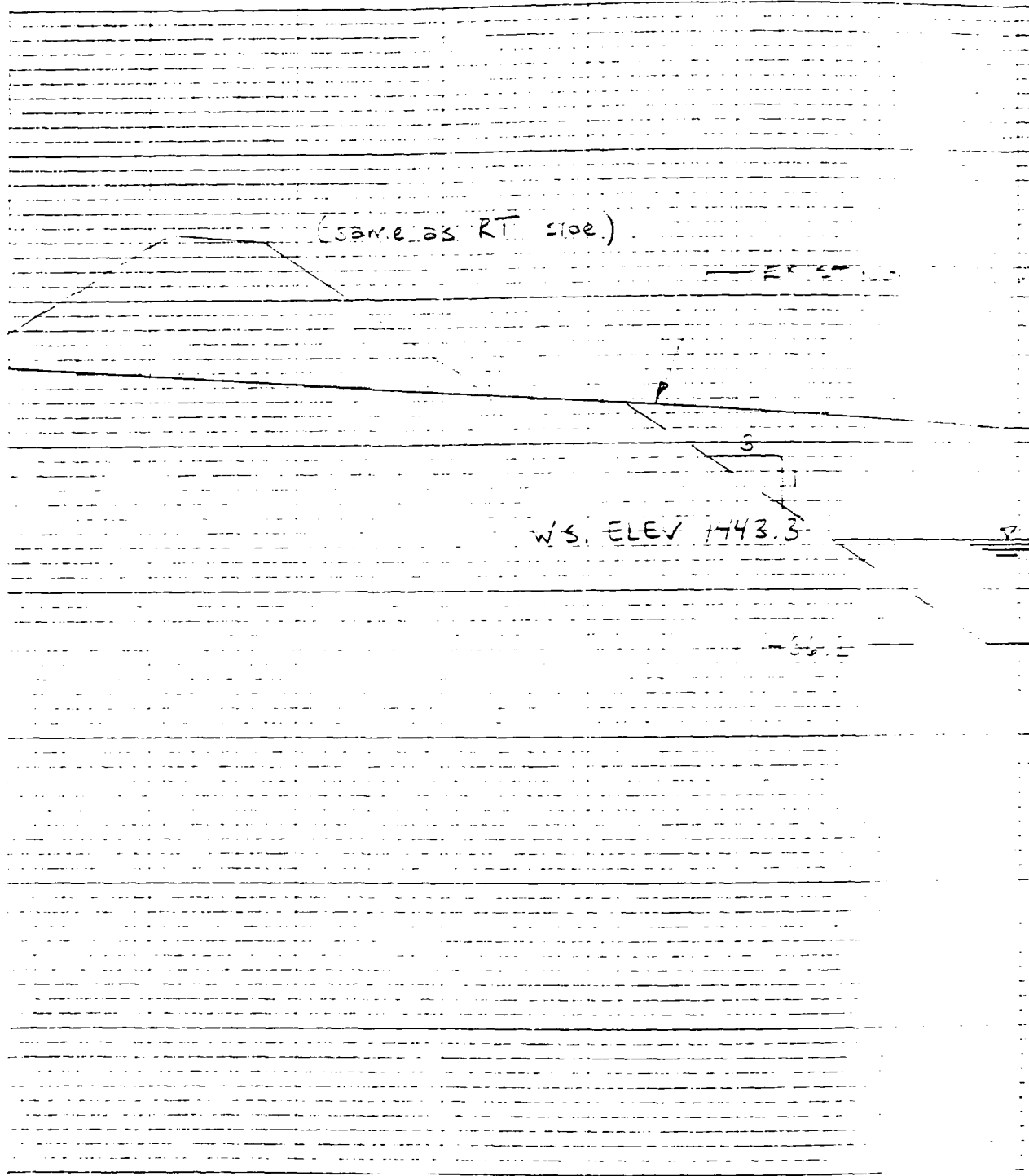
120 LT

80 LT

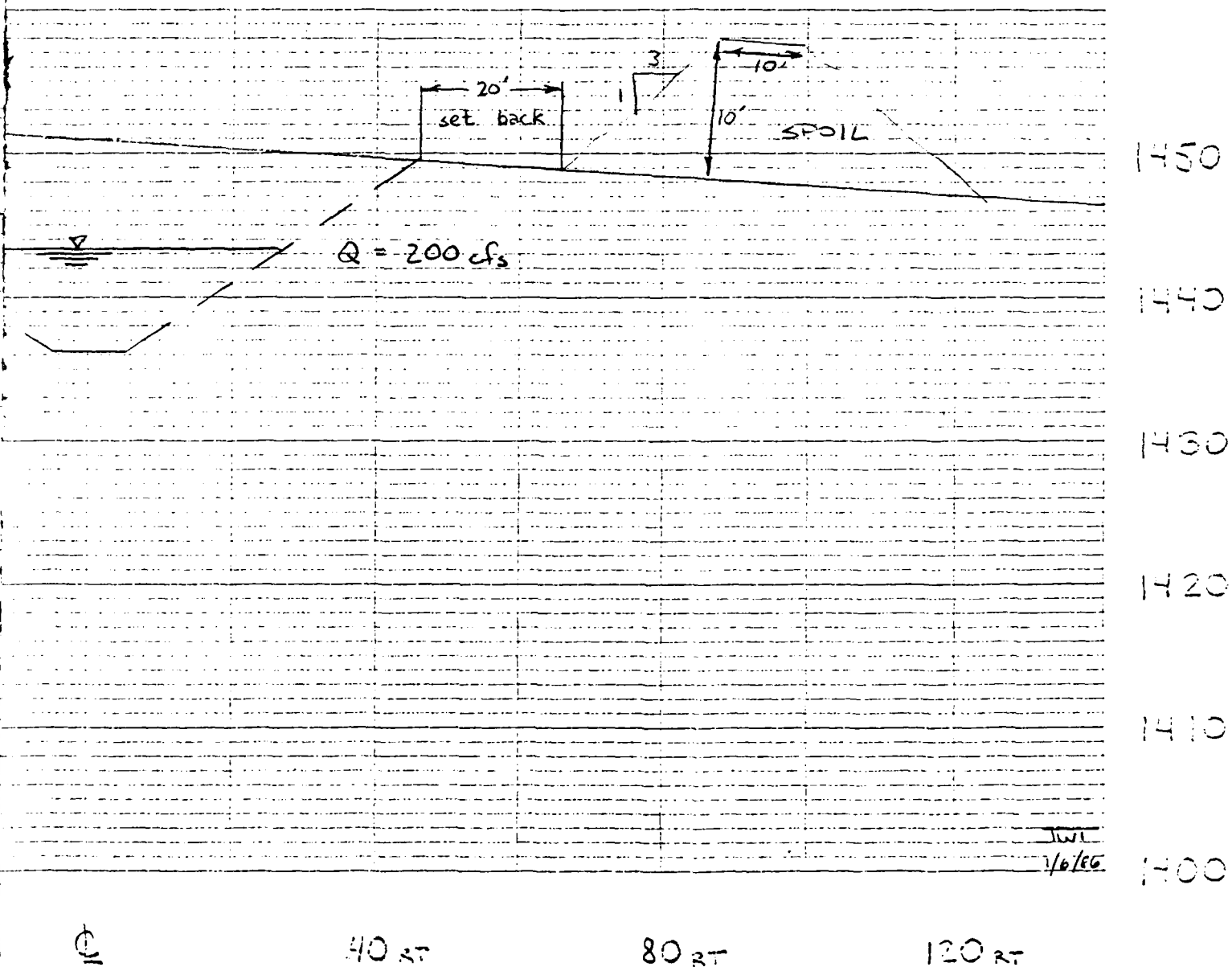
40 LT

(same as RT side)

W.S. ELEV 1443.3



CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H,L  
CROSS SECTION STA 398+00



1450

EXISTING ELEVATION

N.S. EL  
1444

1440

7-1.8

1430

1420

1410

1400

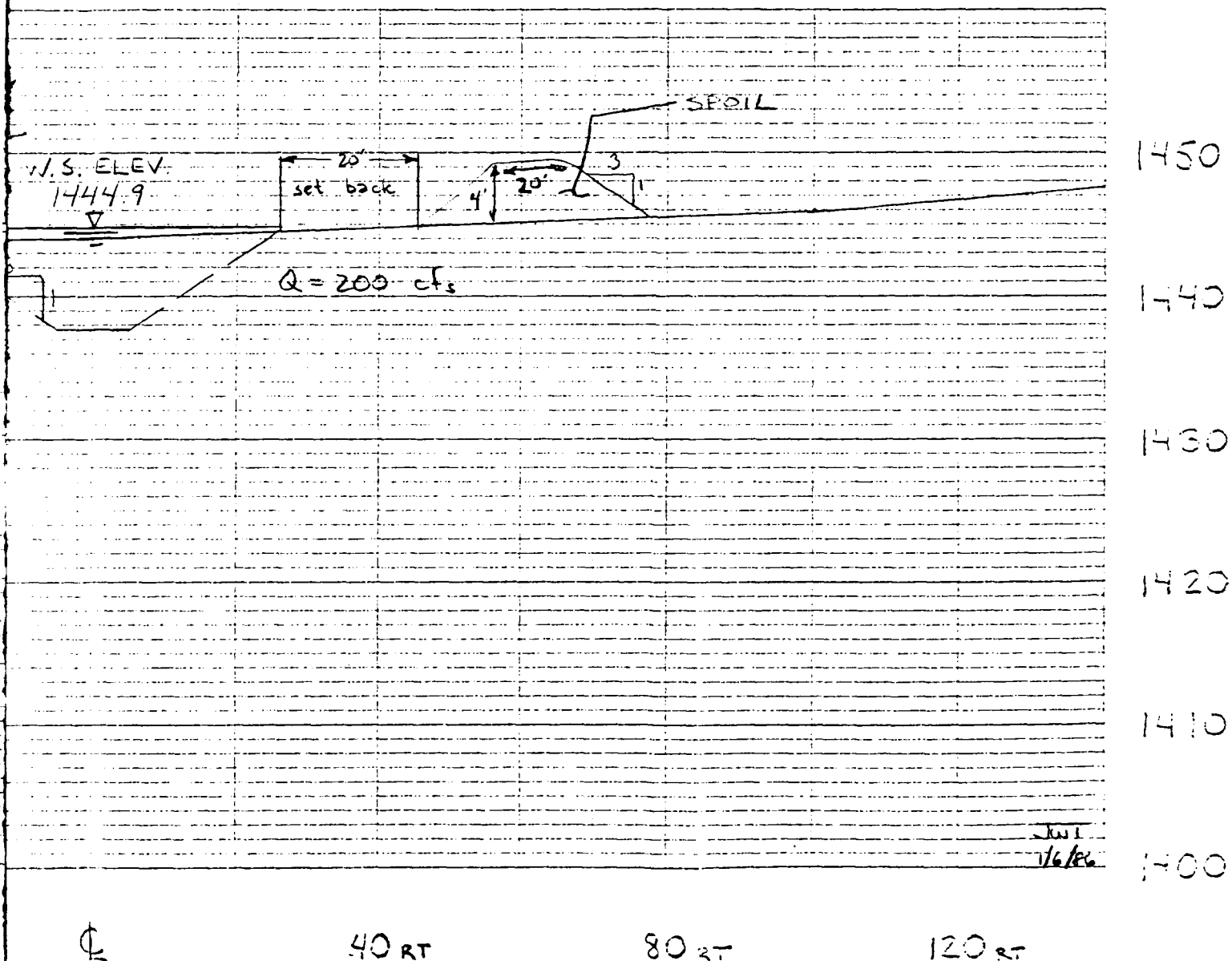
120 LT

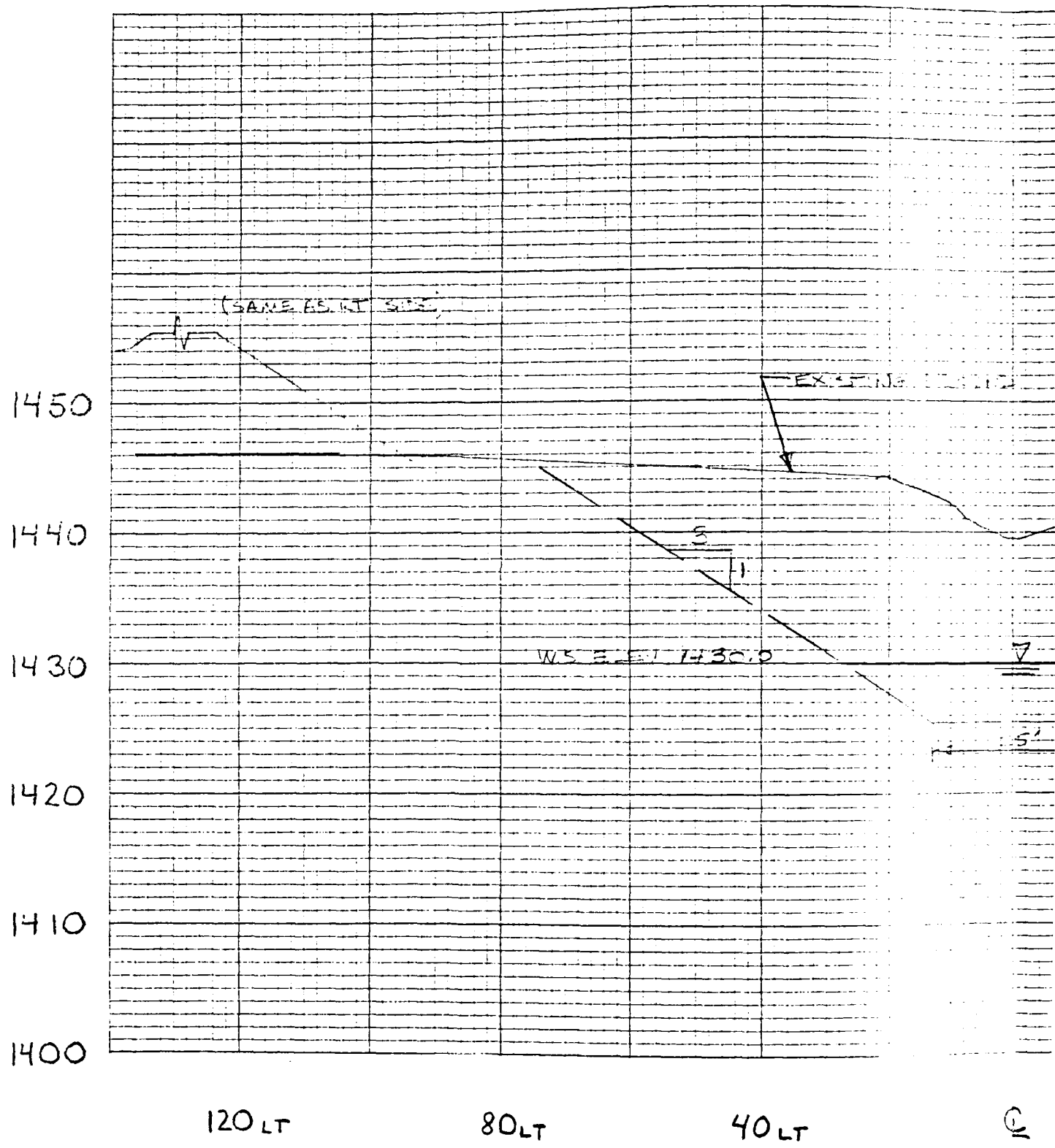
80 LT

40 LT

R

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H,L  
CROSS SECTION STA 485+00

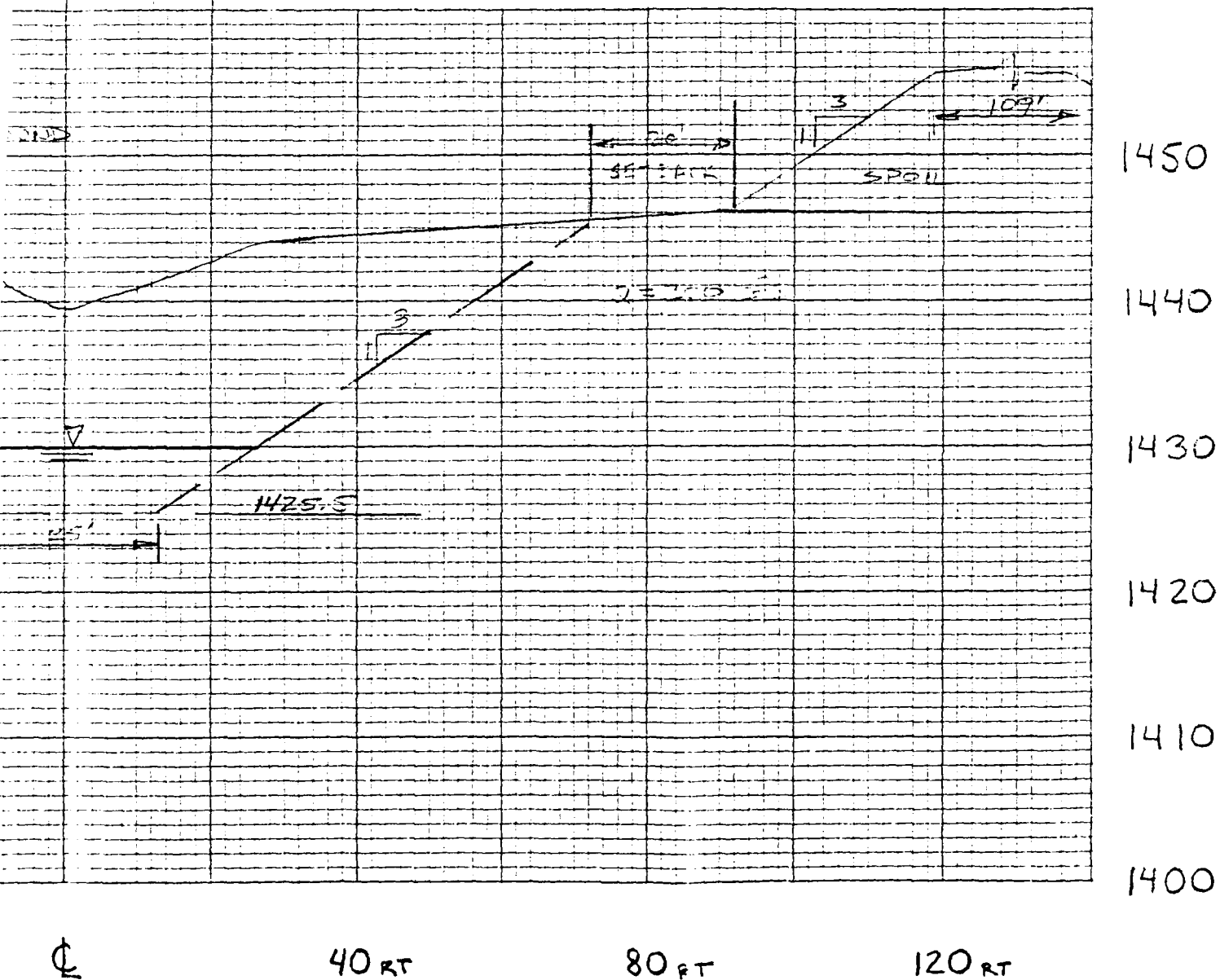




# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 4L

CROSS SECTION STA 5 + 00



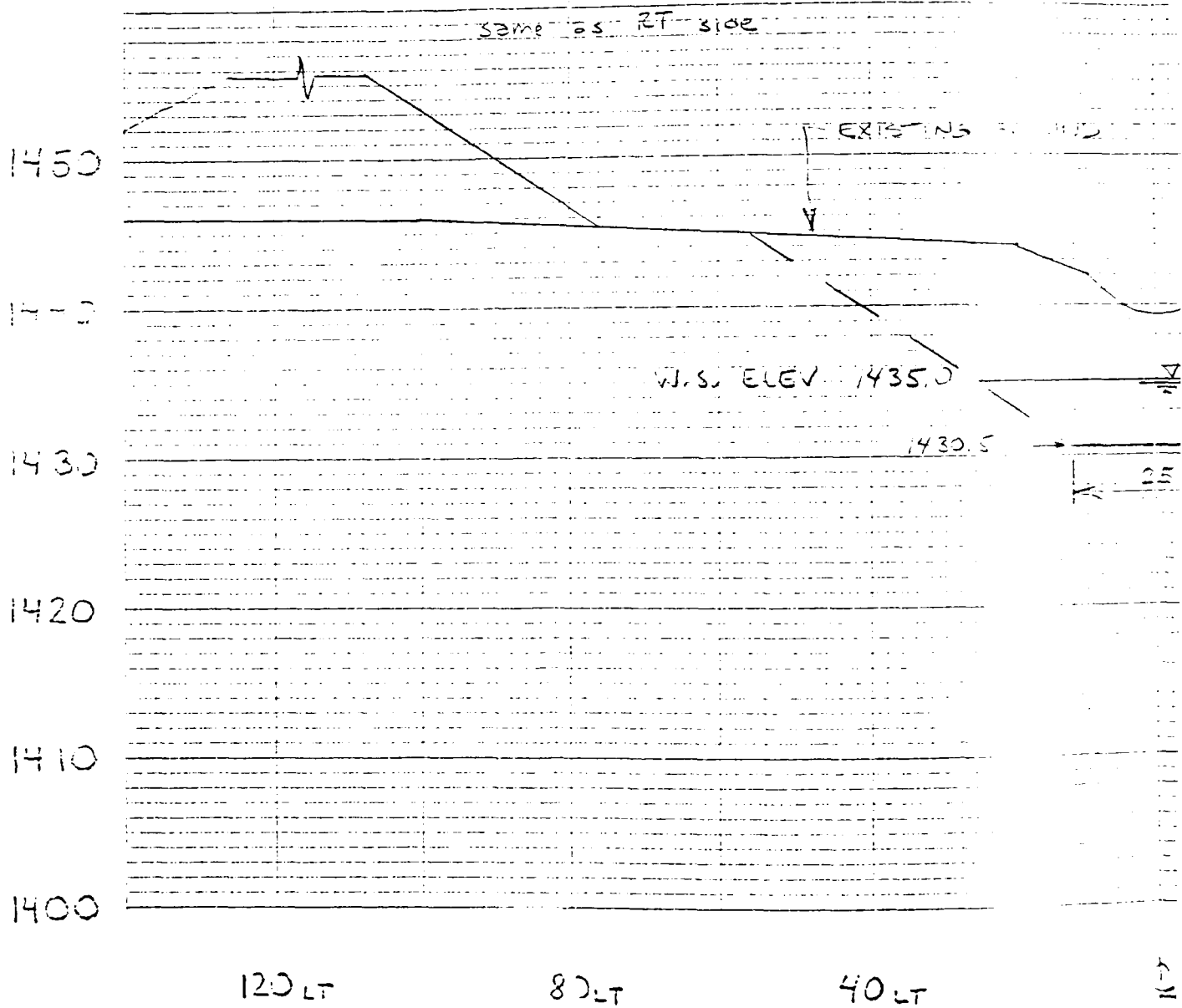
Q

40 RT

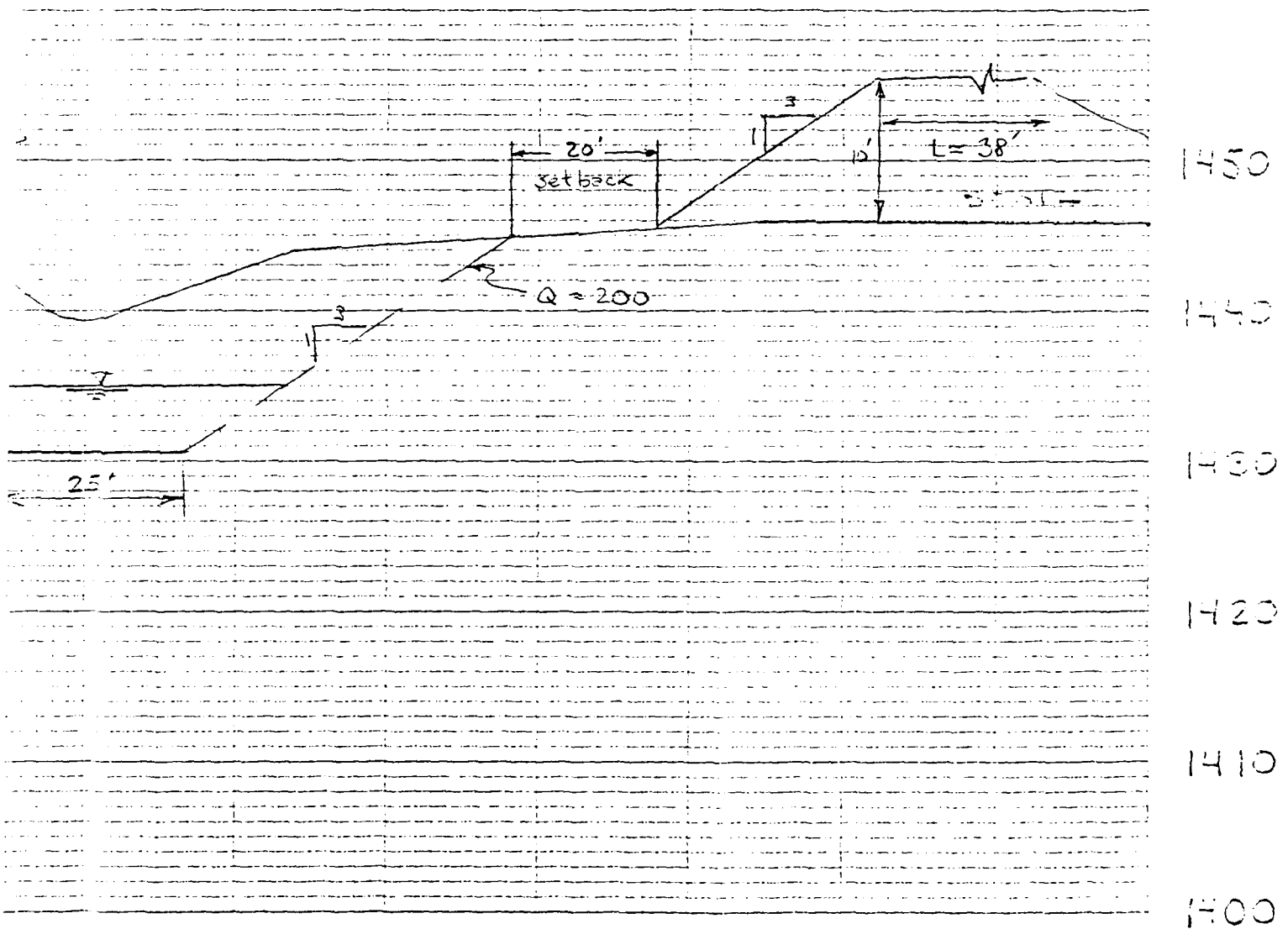
80 FT

120 RT





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 4H  
CROSS SECTION STA 514+00



0

40 RT

80 RT

120 RT

2

PLATE: C-4H

1450

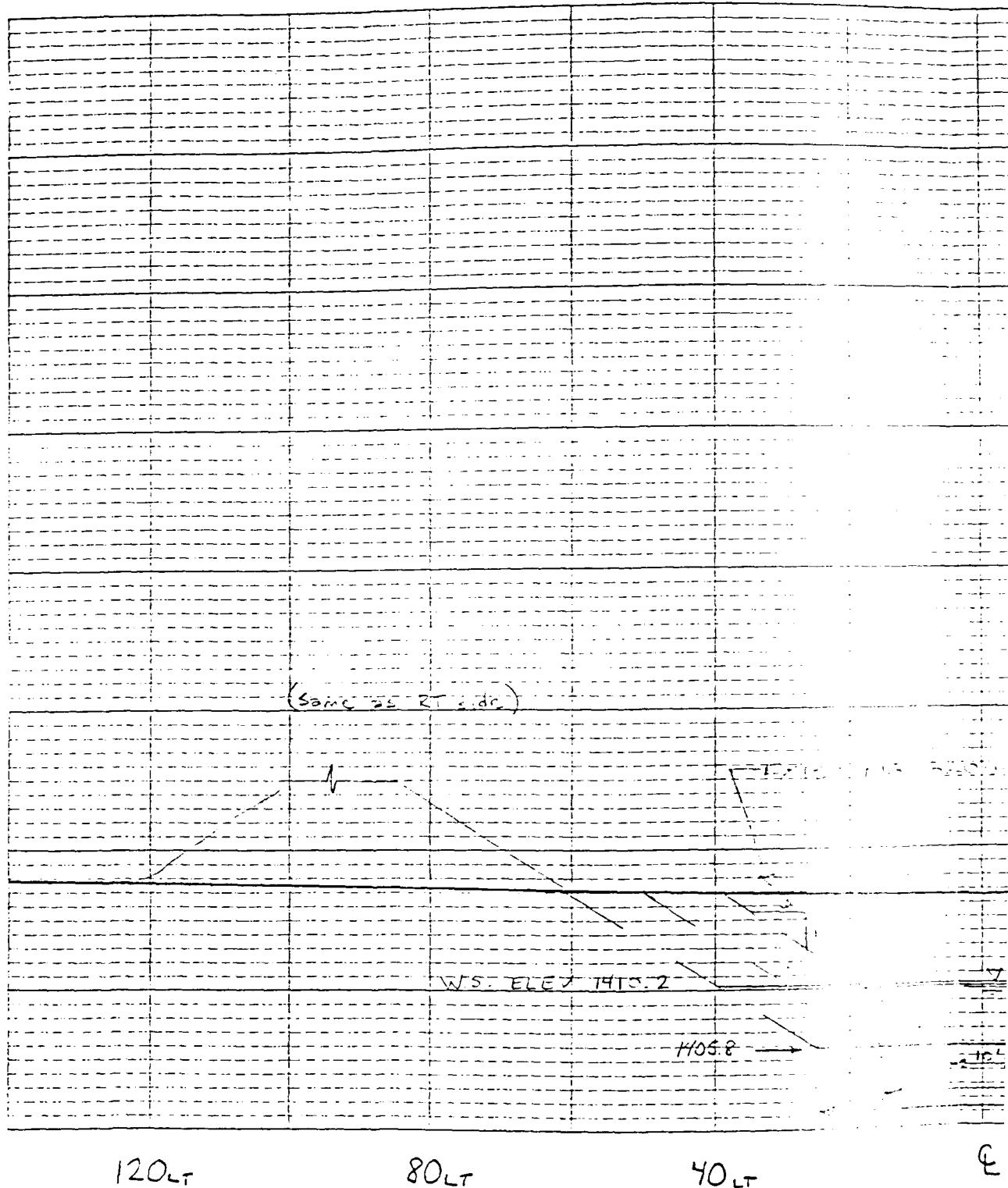
1440

1430

1420

1410

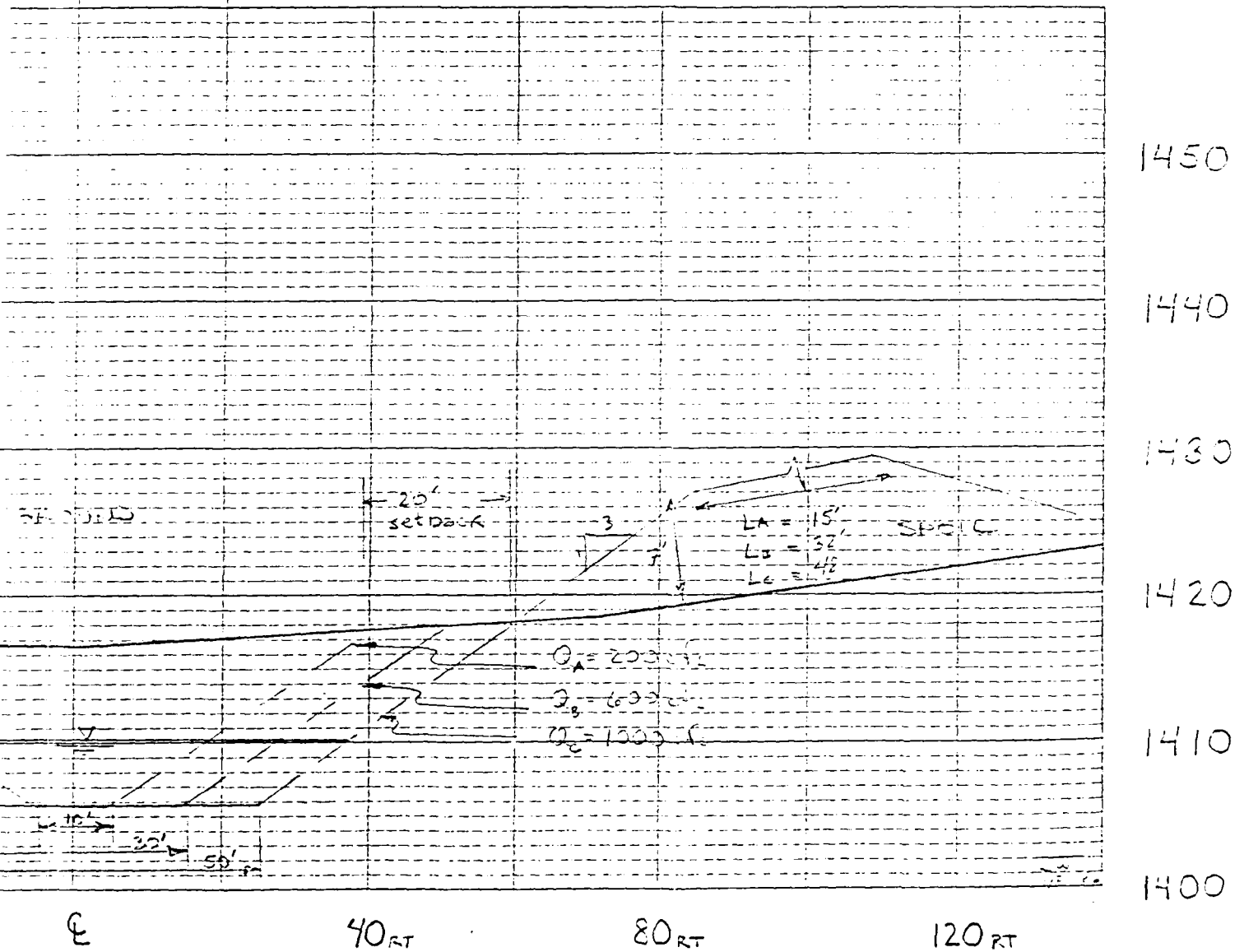
1400

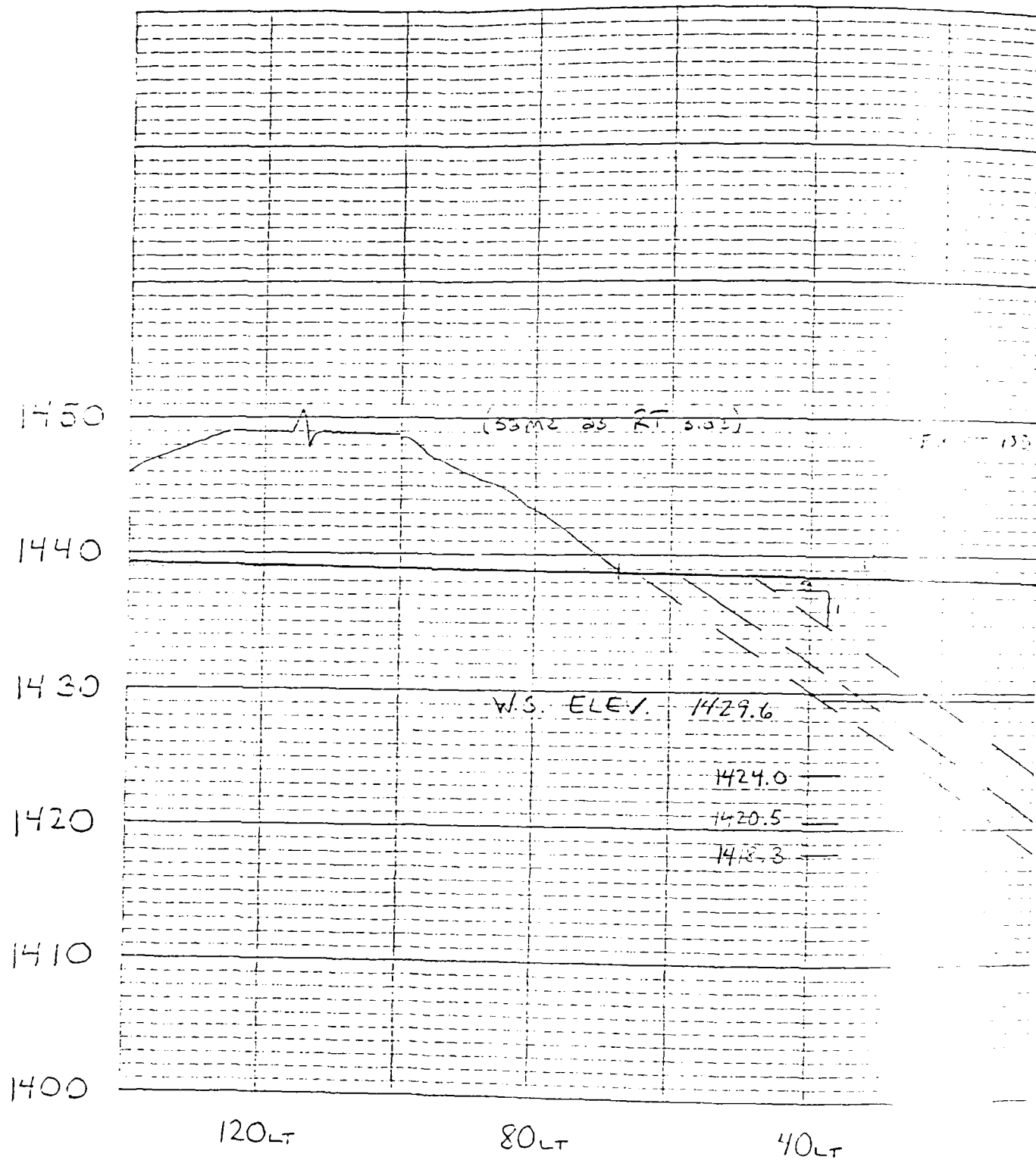


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 5A E.C.

CROSS SECTION STA 25+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE SA, B, C  
CROSS SECTION STA 70+00

SCOURED

20' set back

$Q_A = 200 \text{ cfs}$   
 $Q_B = 600 \text{ cfs}$   
 $Q_C = 1000 \text{ cfs}$

$L_A = 4'$   
 $L_B = 22'$   
 $L_C = 35'$

1450  
1440  
1430  
1420  
1410  
1400

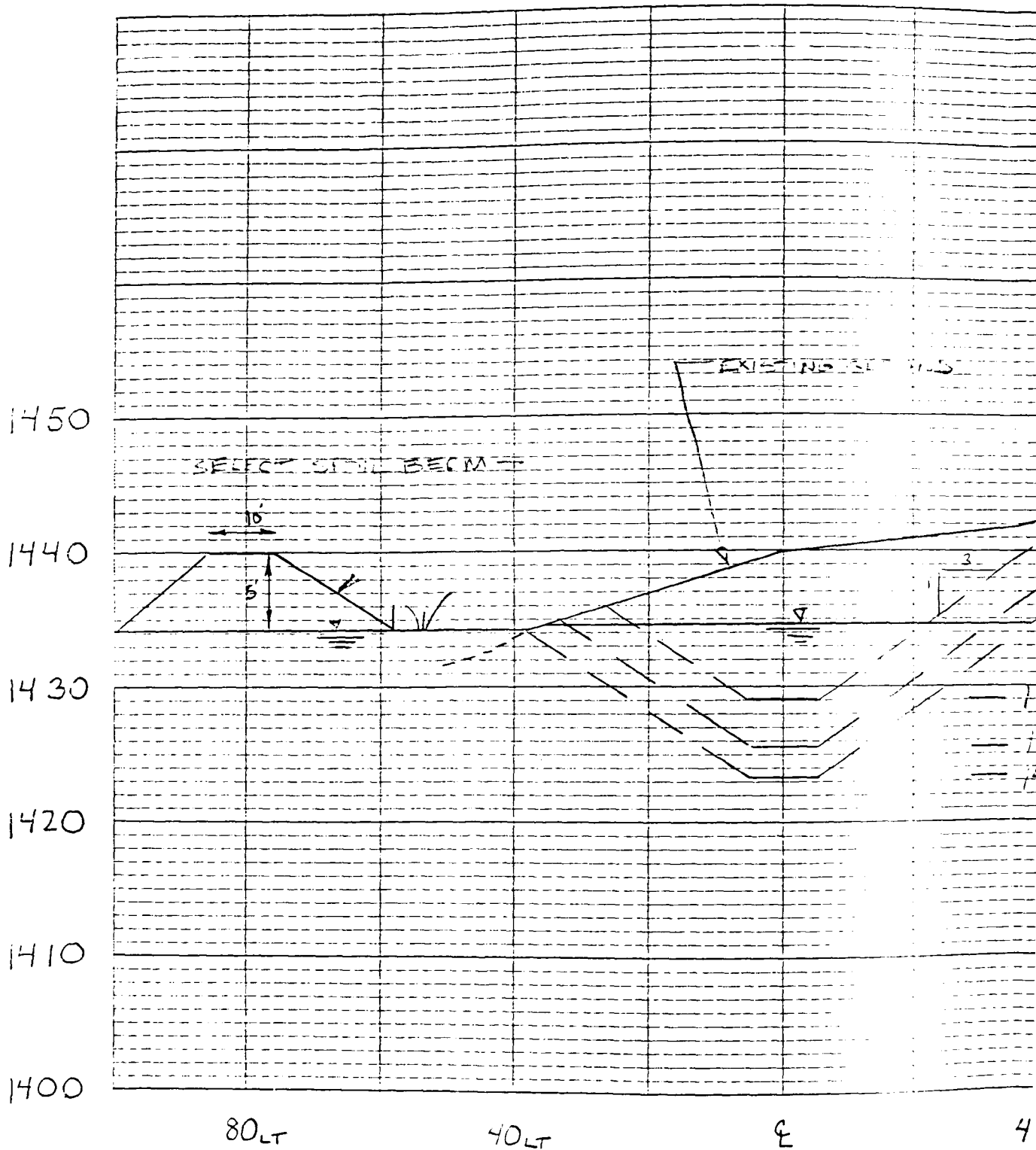
40 RT

80 RT

120 RT

2

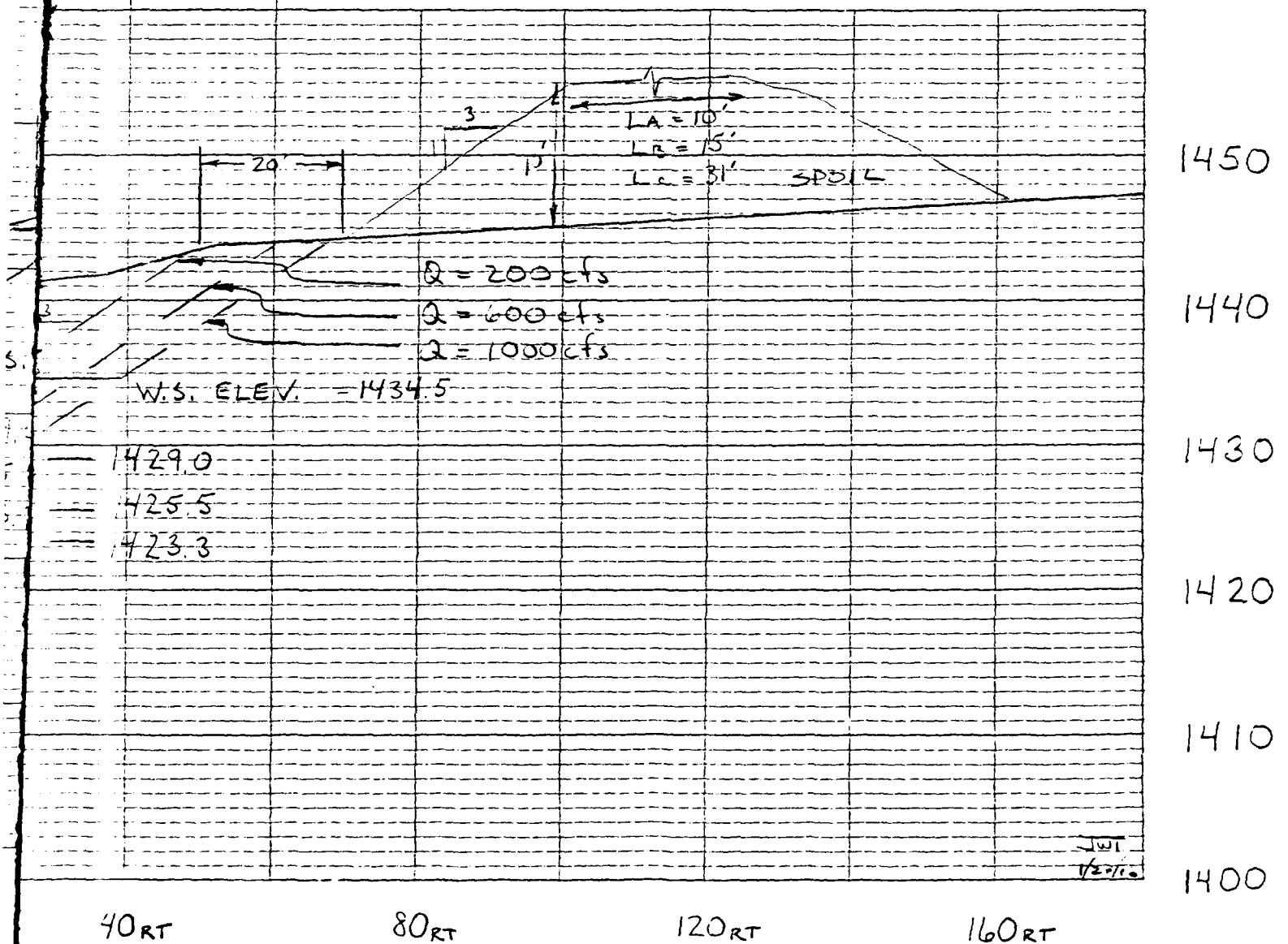
PLATE C



1134.04  
 428.04  
 20 87  
 22 84

1

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 5A, B, & C CROSS SECTION STA 120+00





1450

(same as RT side)

1440

W.S. ELEV. = 1435.7

1430

1430.1

1426.6

1424.4

1420

1410

1400

120 LT

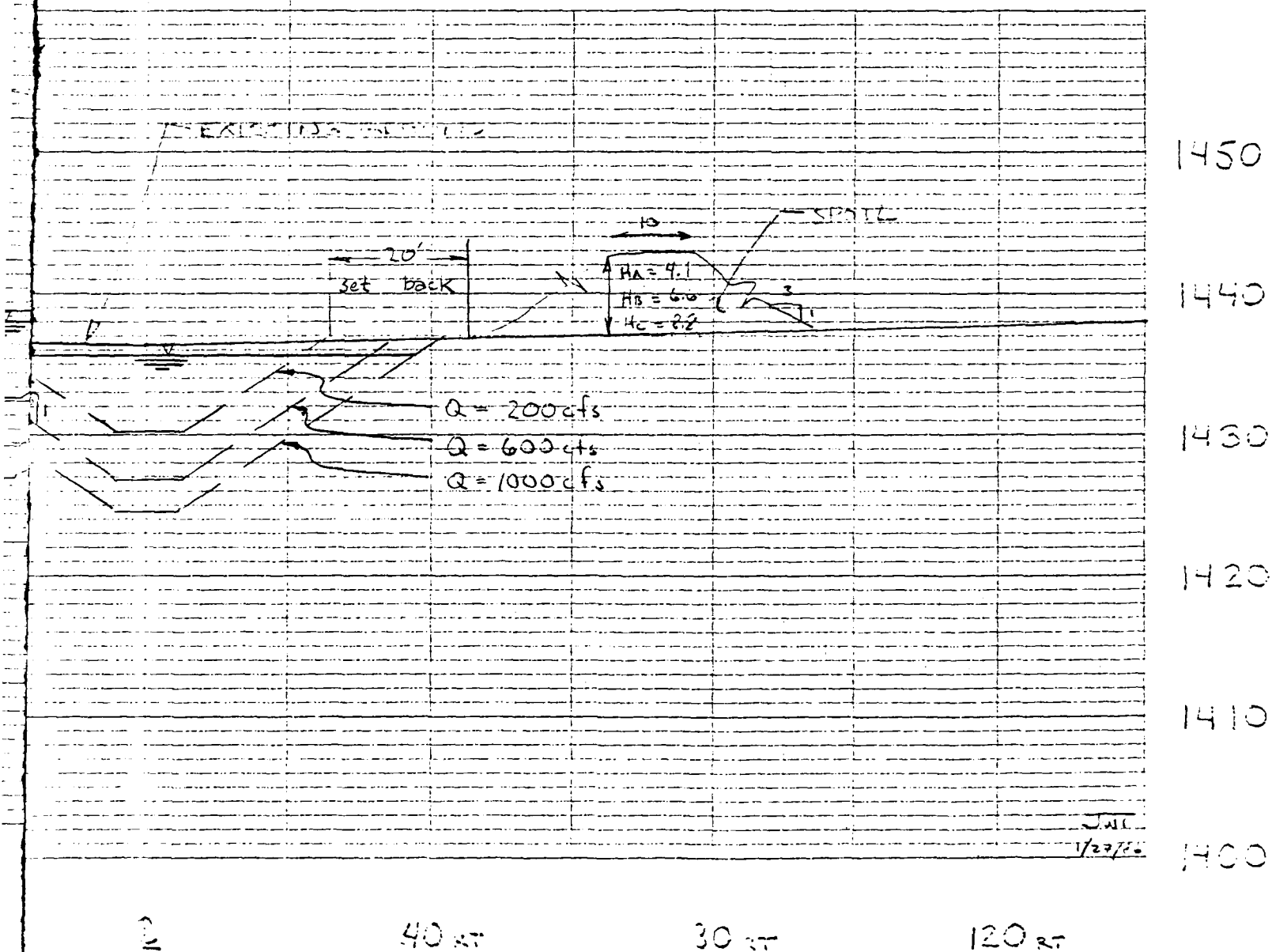
20 LT

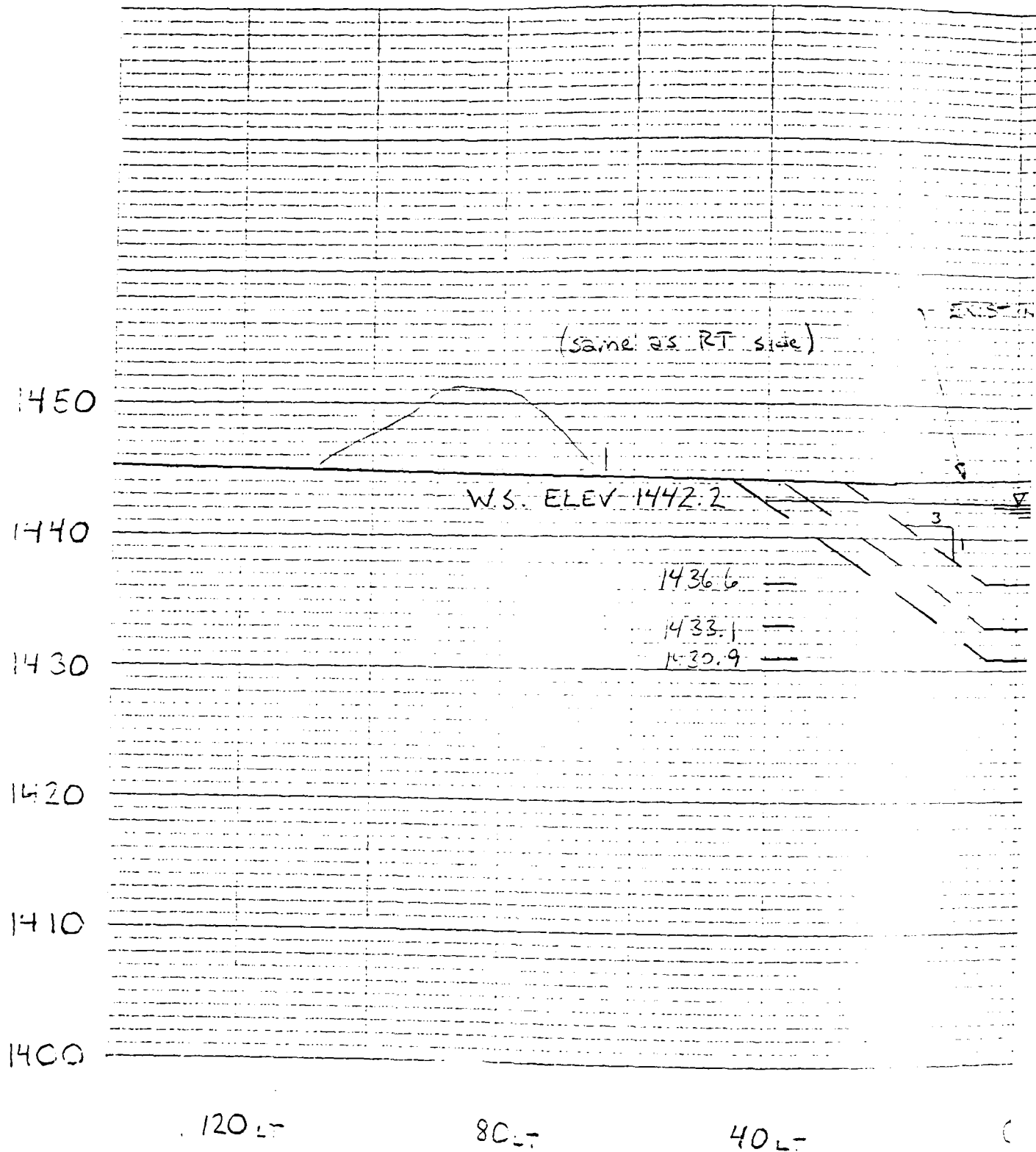
40 LT

1435.7  
1430.1  
20.6  
24.4

1

# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE CASE 5 A, B, & C CROSS SECTION STA 170+00

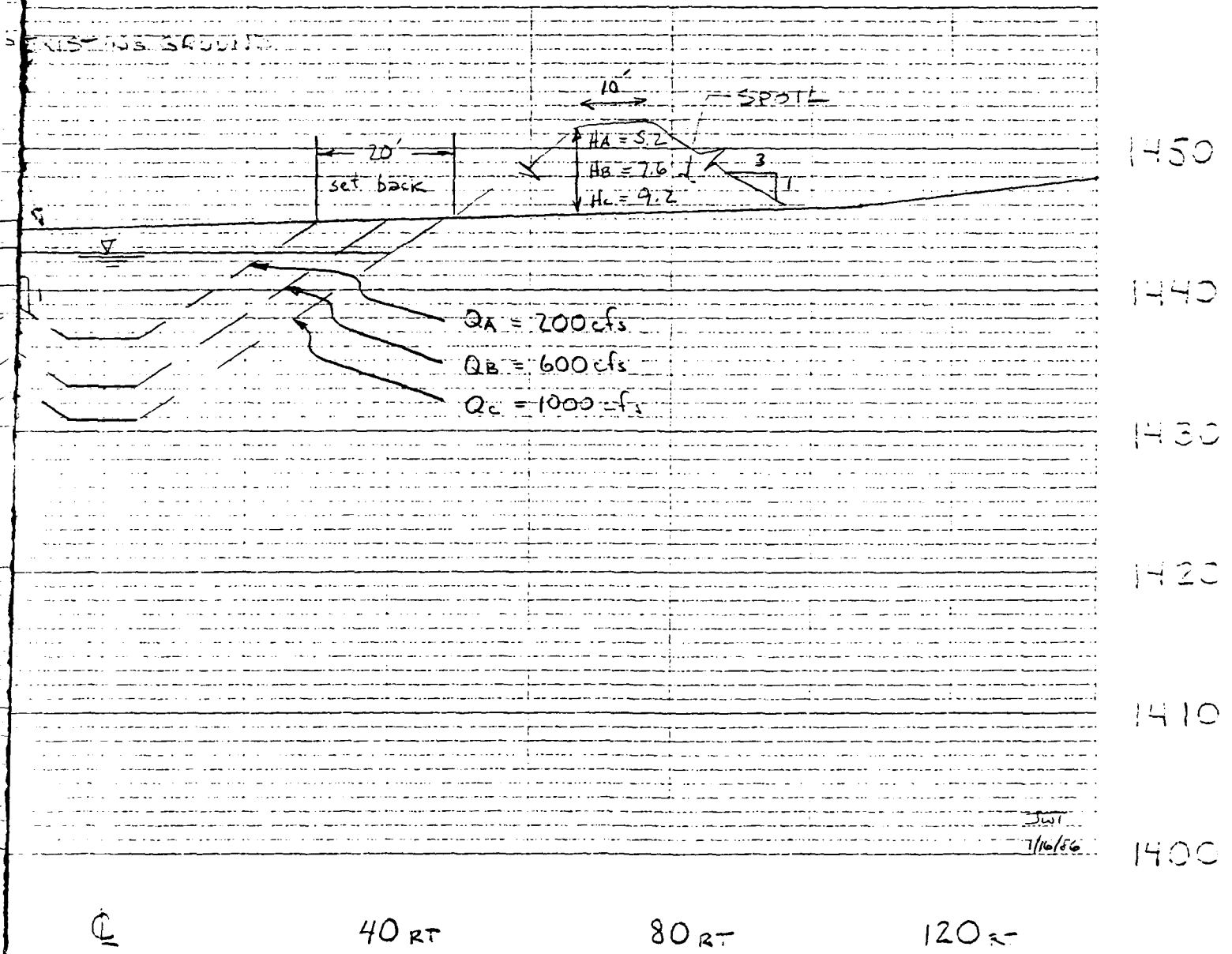


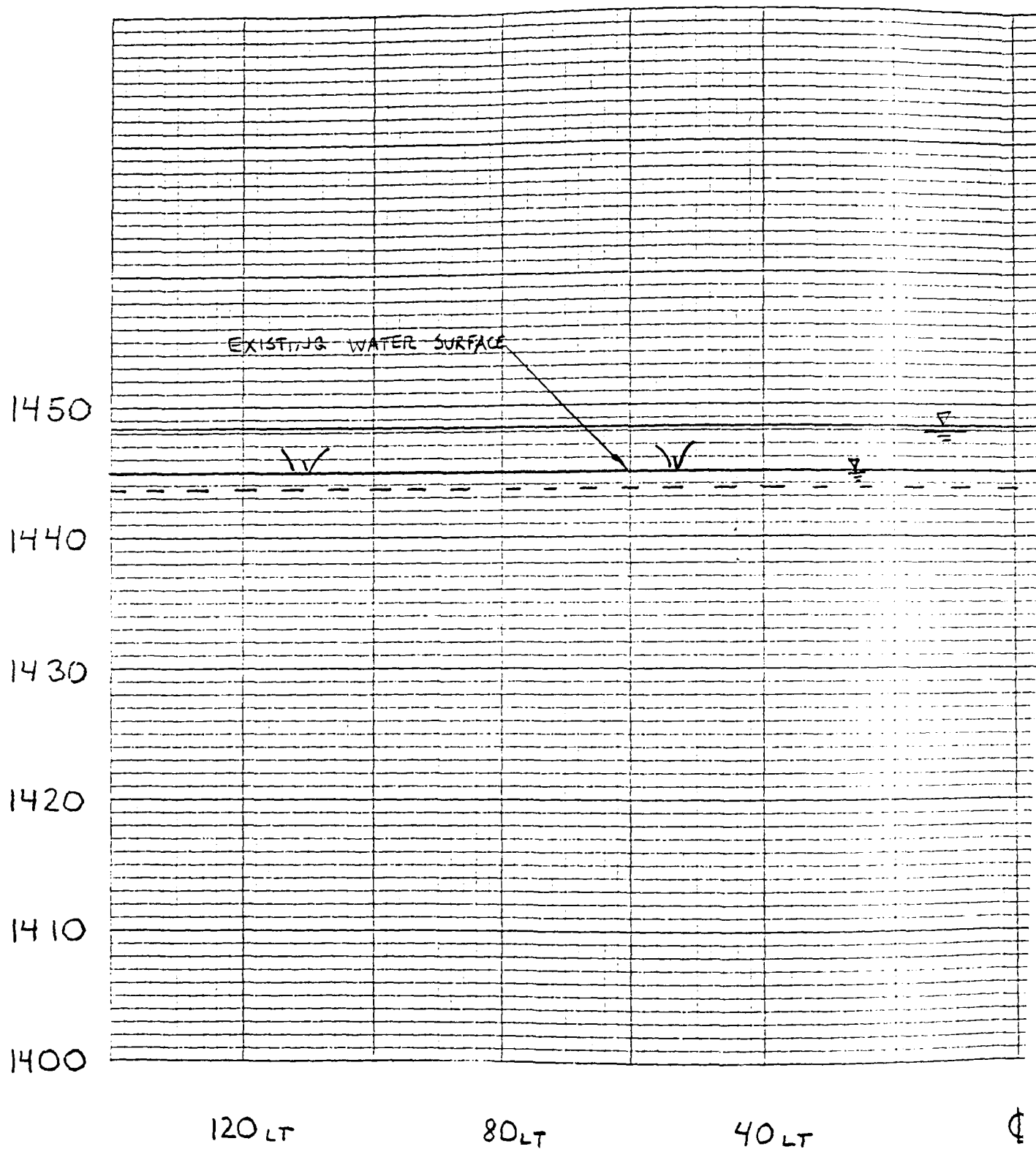


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 5 A, B, & C

CROSS SECTION STA 210+00

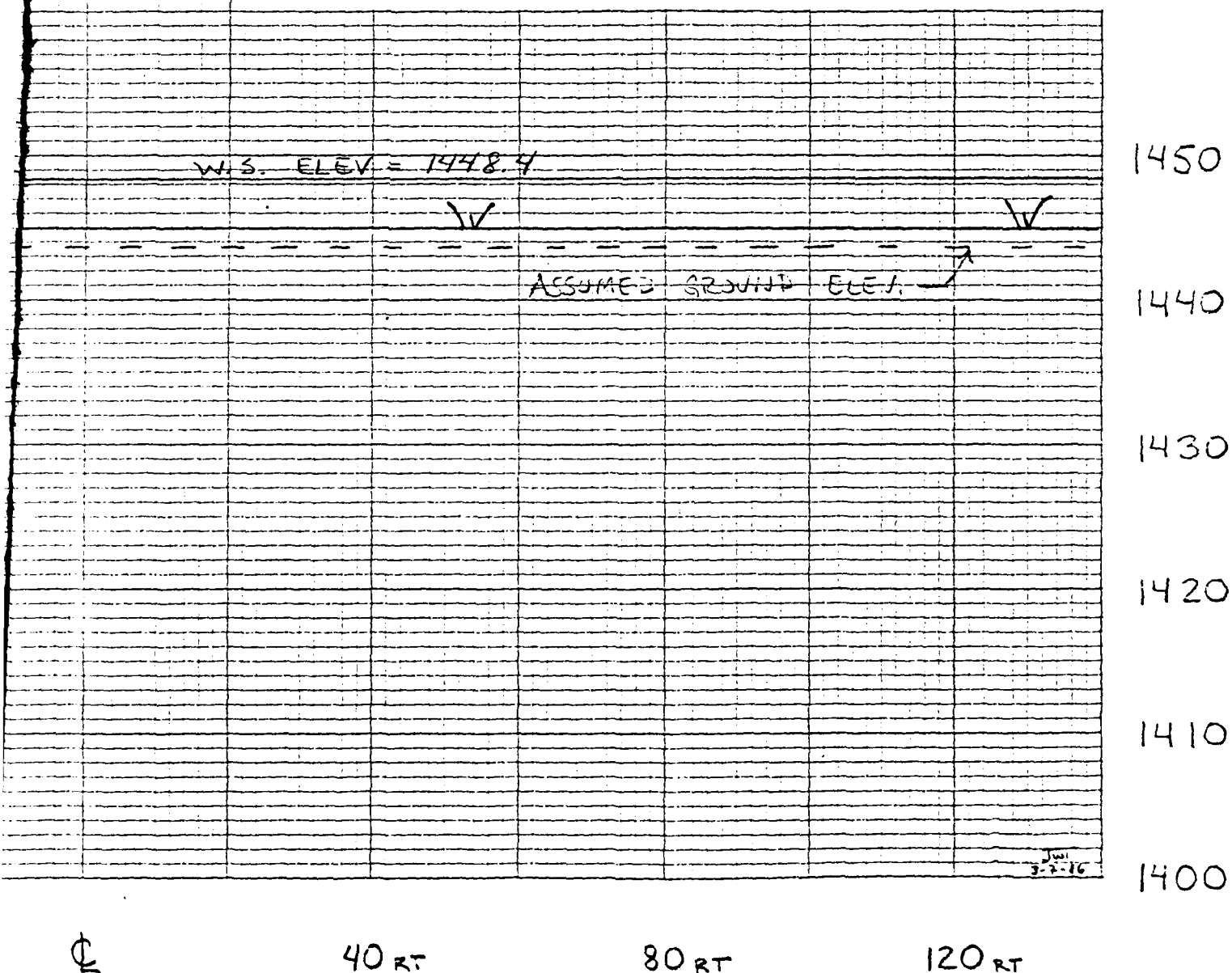


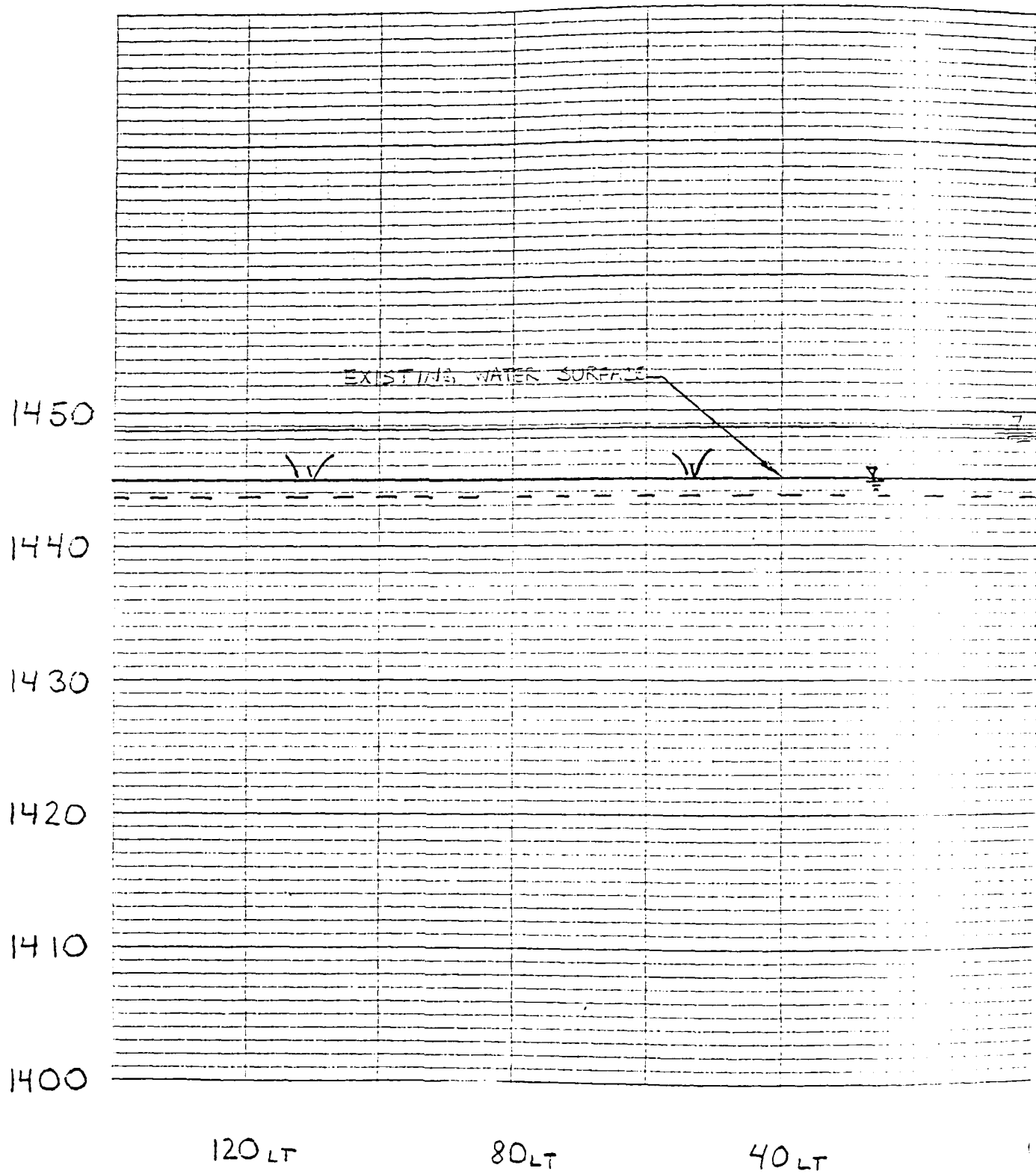


CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE S A, B, & C

CROSS SECTION STA 244+00





1

CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE

CASE 5A, B, & C

CROSS SECTION STA 275+00

W.S. = 1448.7

ASSUMED 3200.1 - ELEV

1450

1440

1430

1420

1410

1400

3-2-16

0

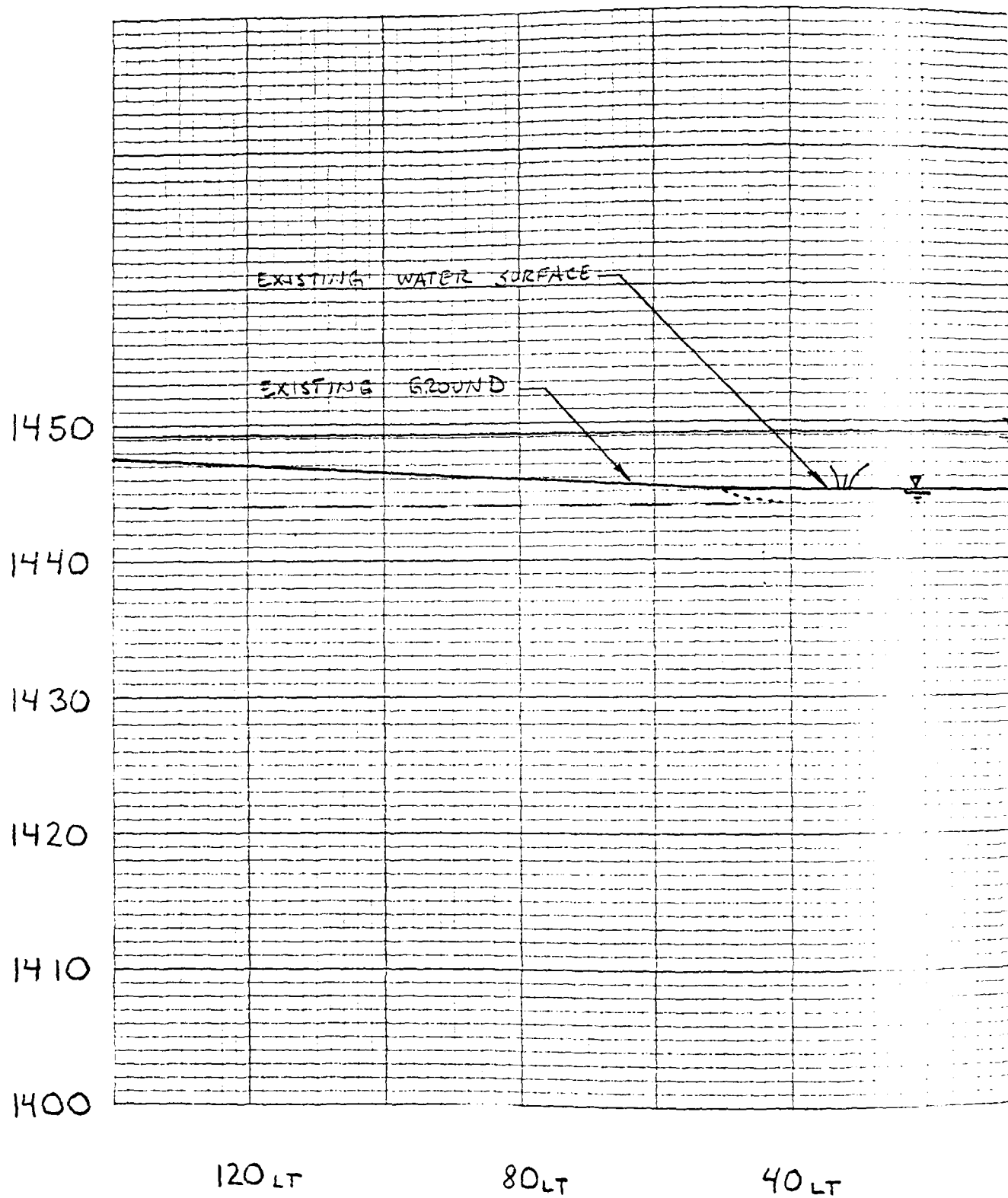
40 RT

80 RT

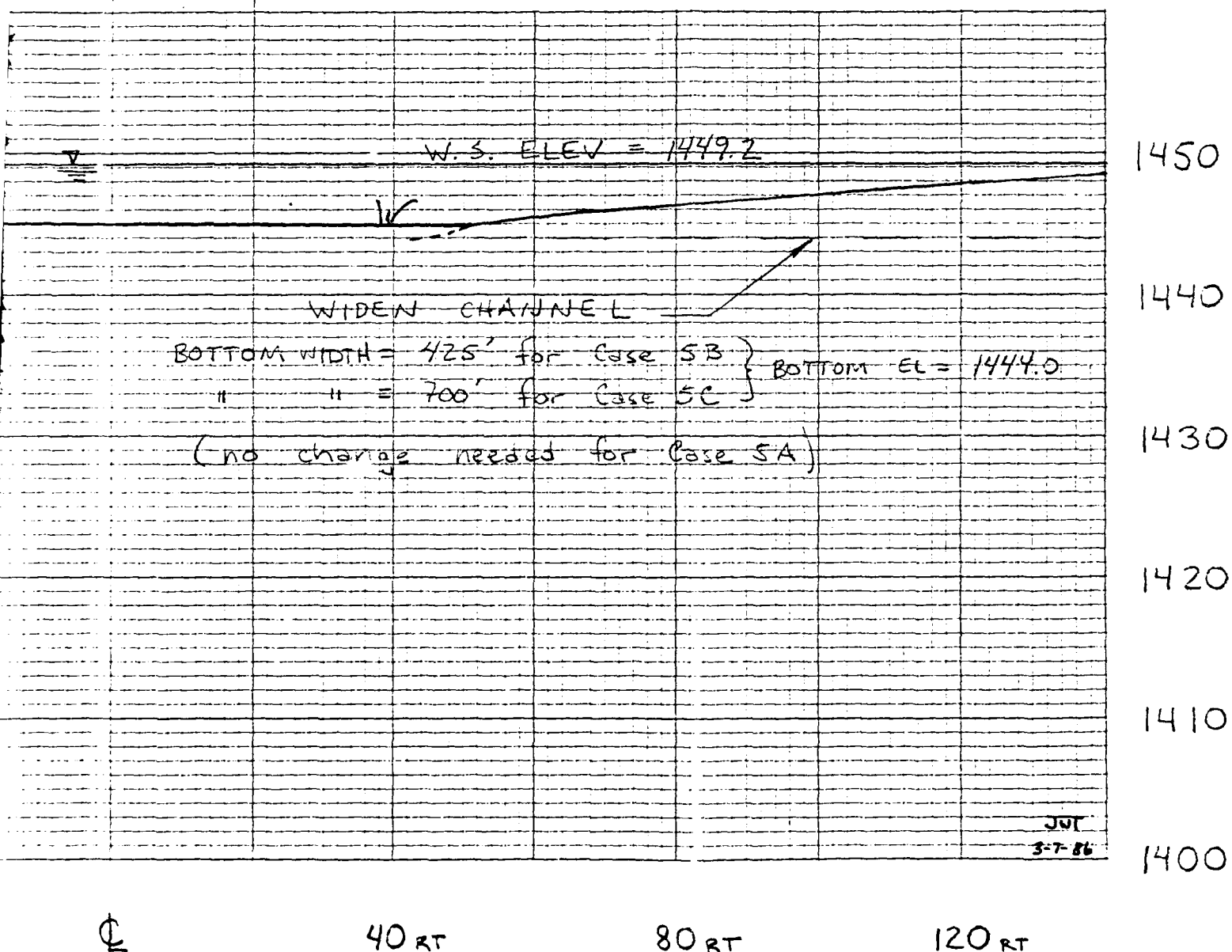
120 RT

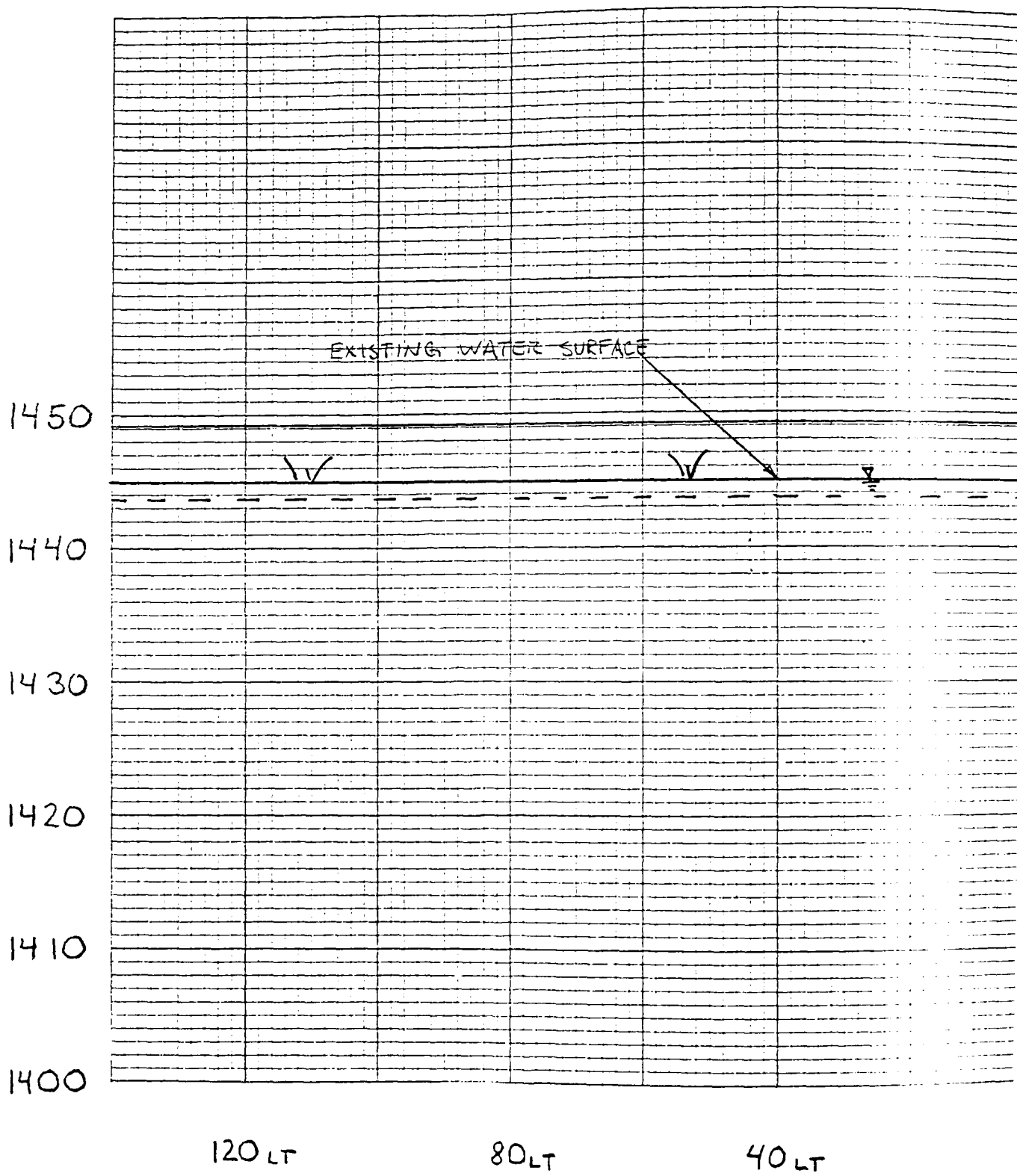
PLATE C-23



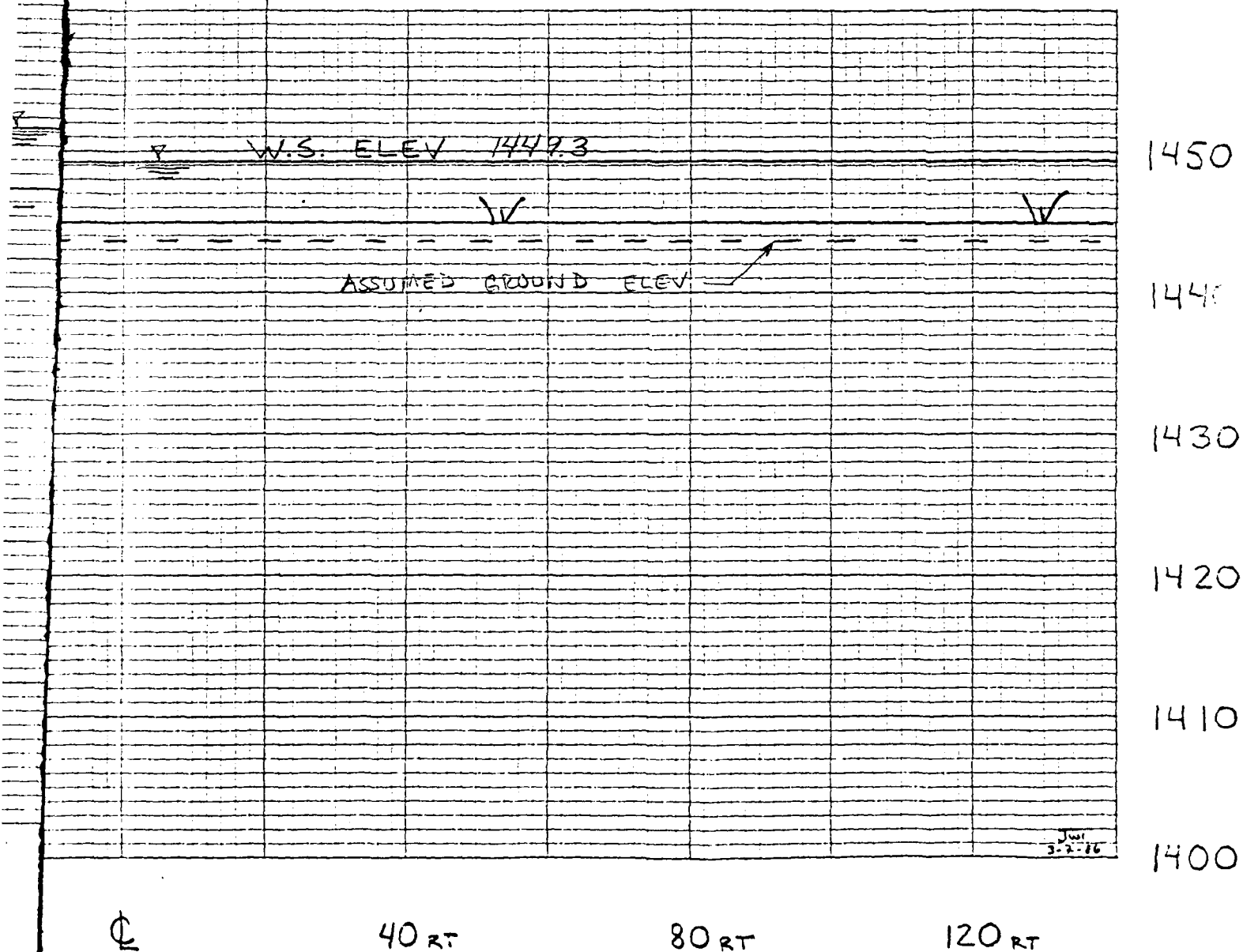


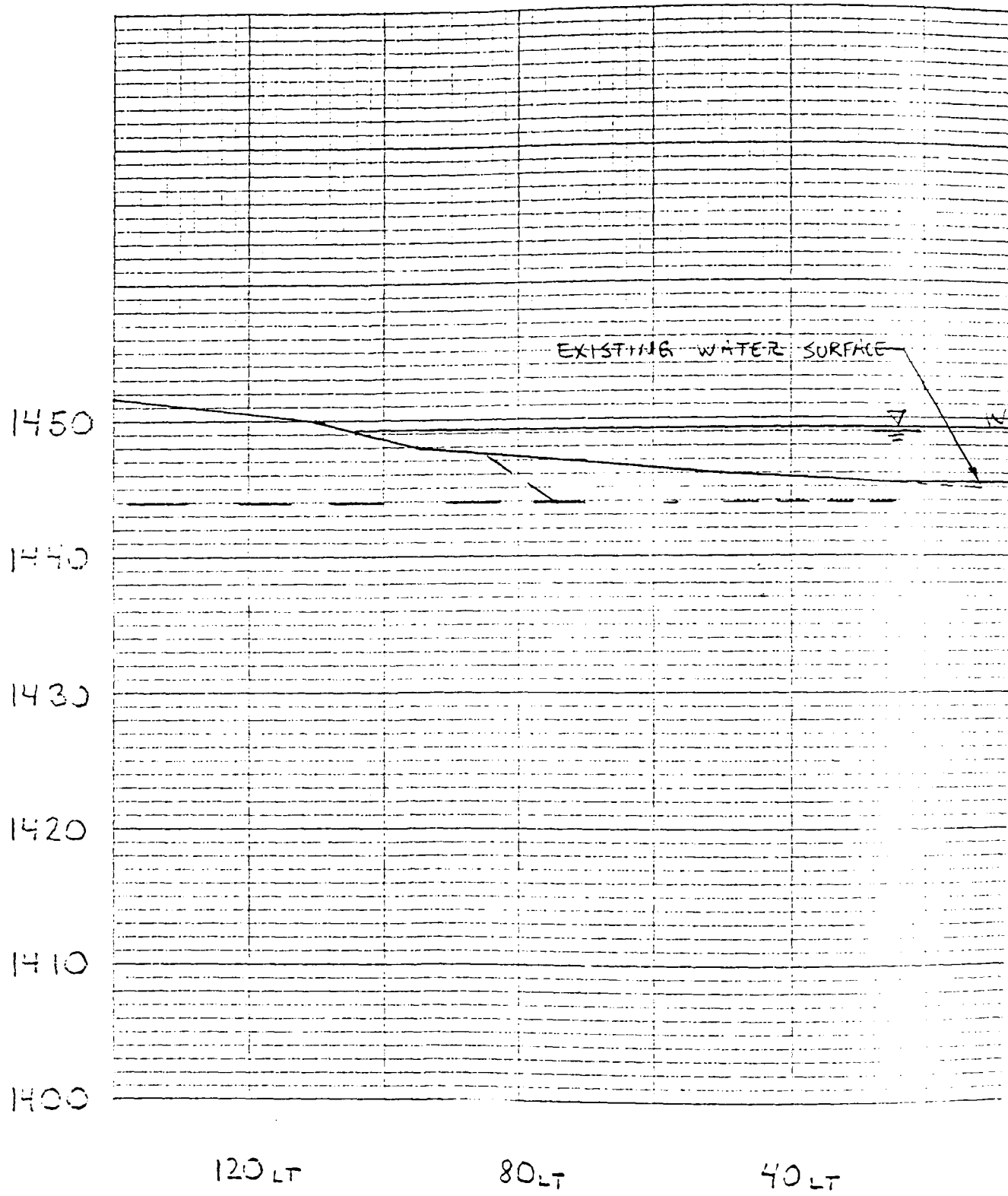
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE S A, B, & C  
CROSS SECTION STA 304+00





CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 5 A, B, & C  
CROSS SECTION STA 345+00

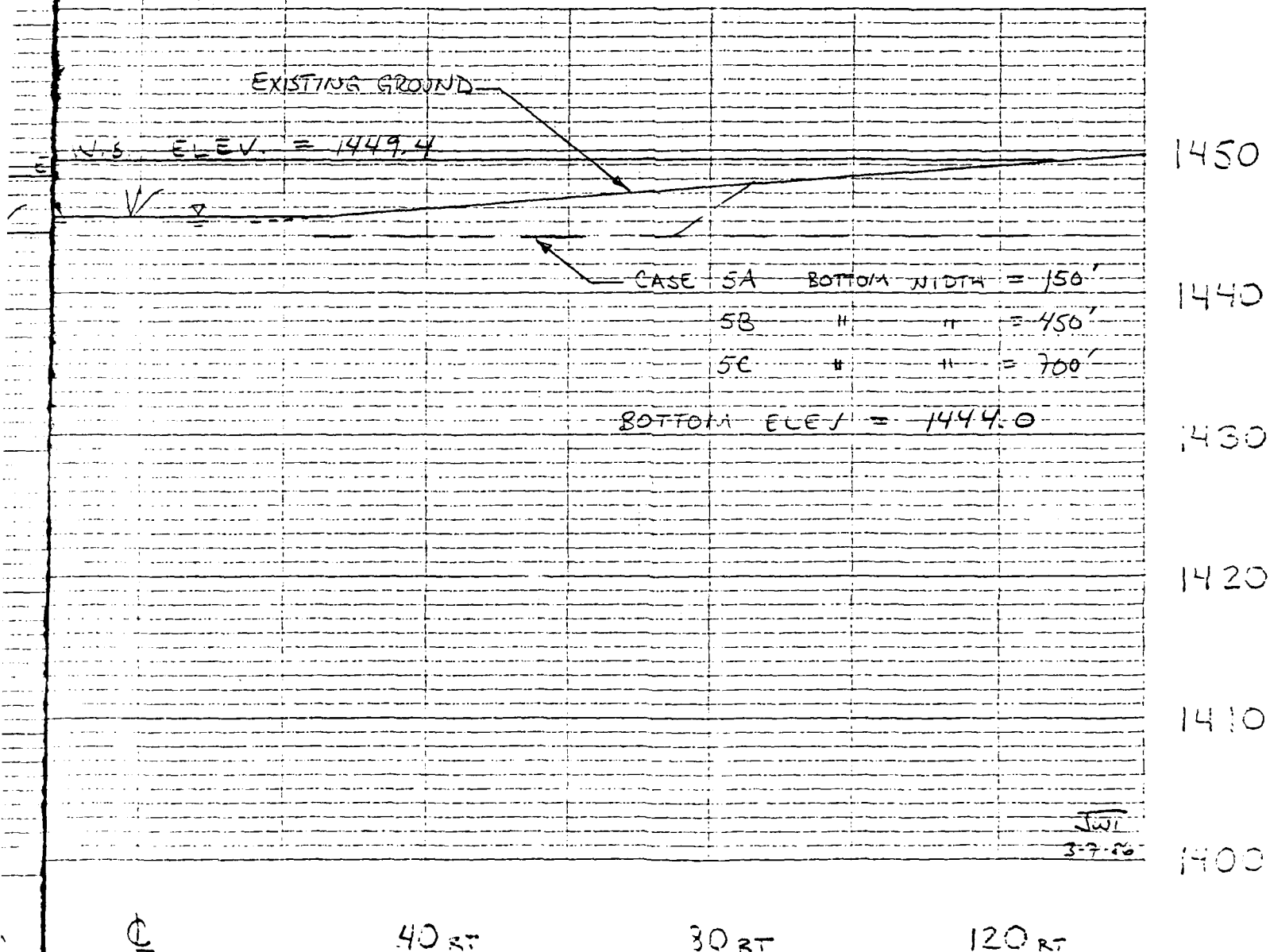


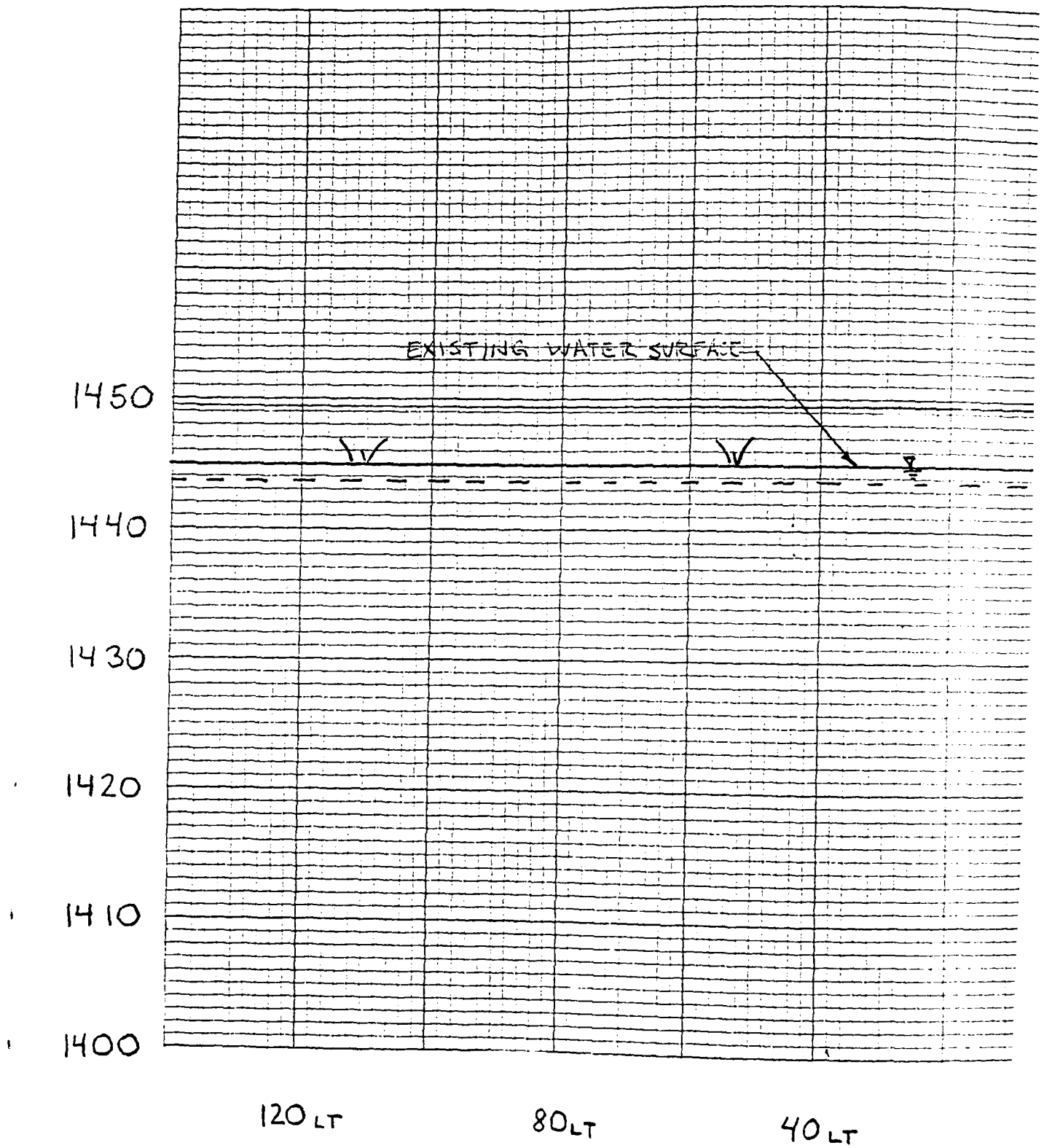


# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

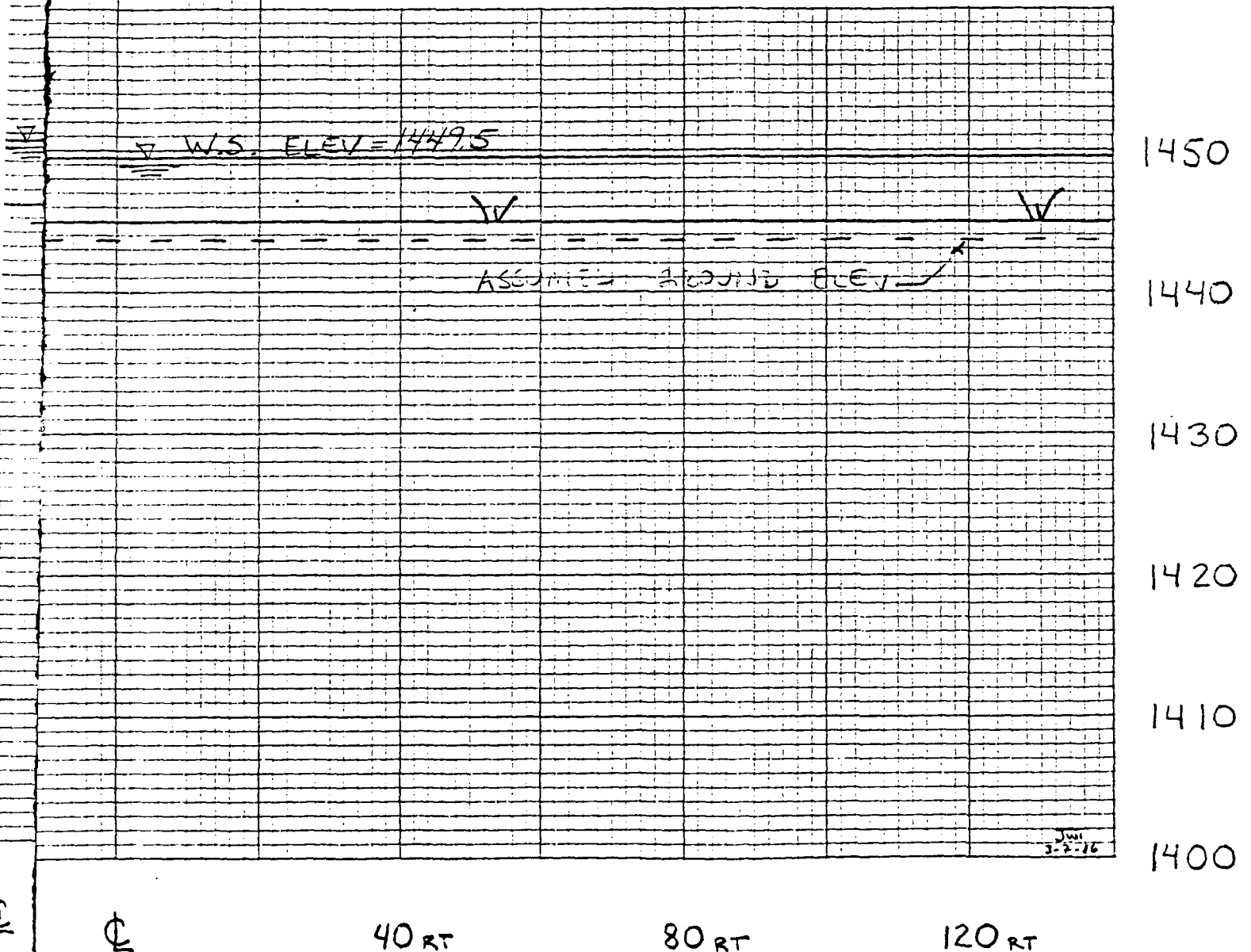
CASE 5 A, B, & C

CROSS SECTION STA 370+00

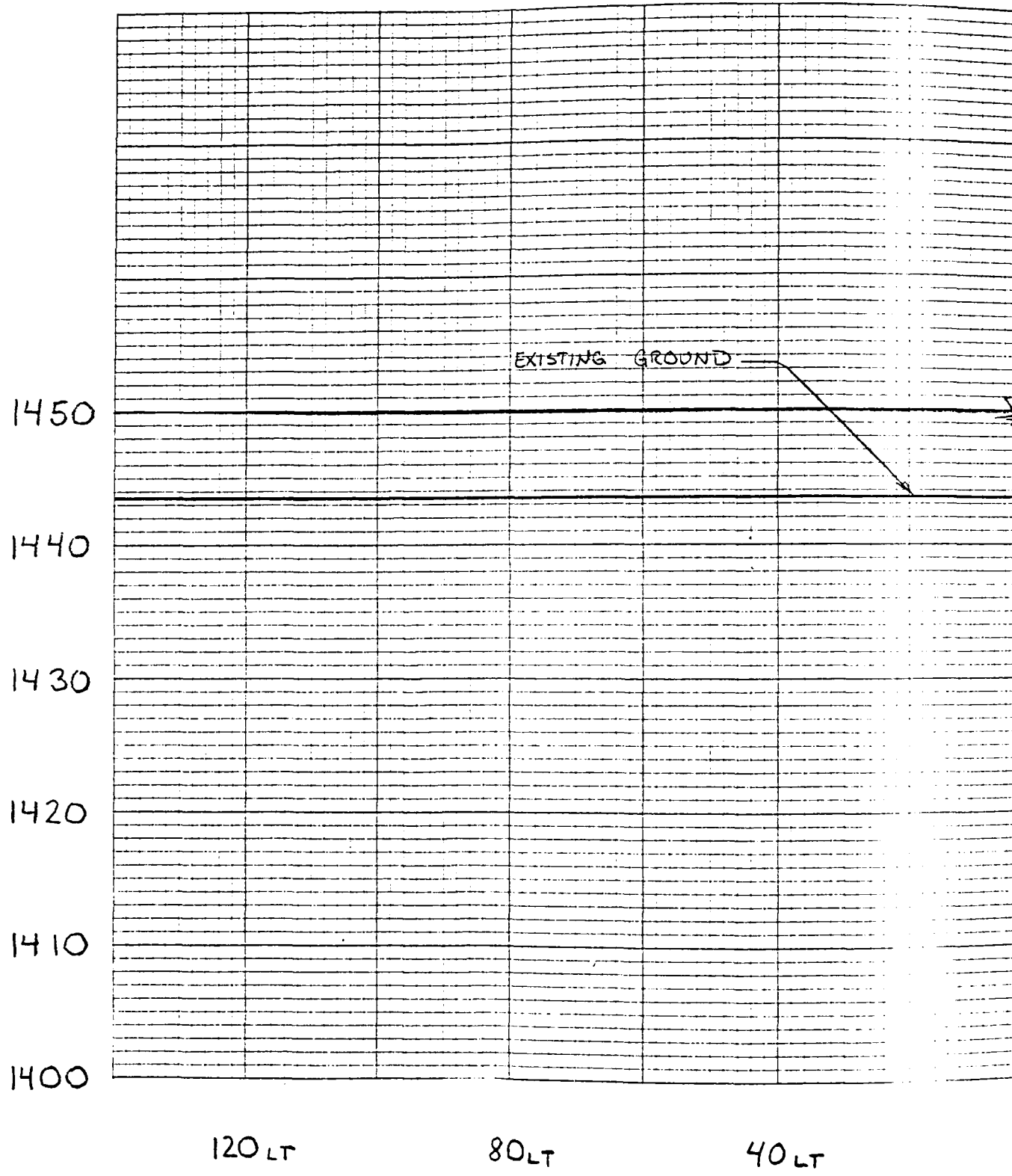




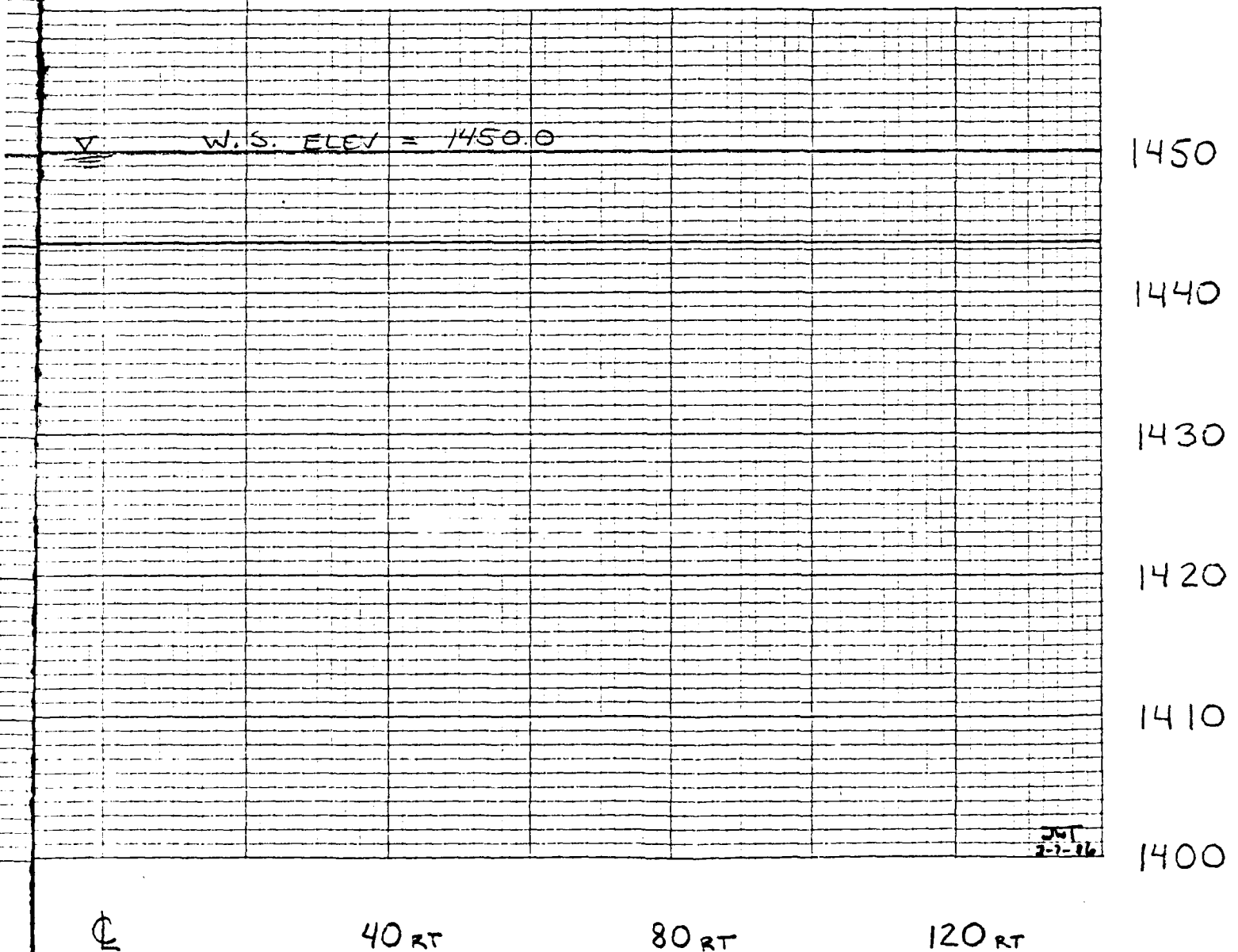
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 5 A, B, & C  
CROSS SECTION STA 398+00

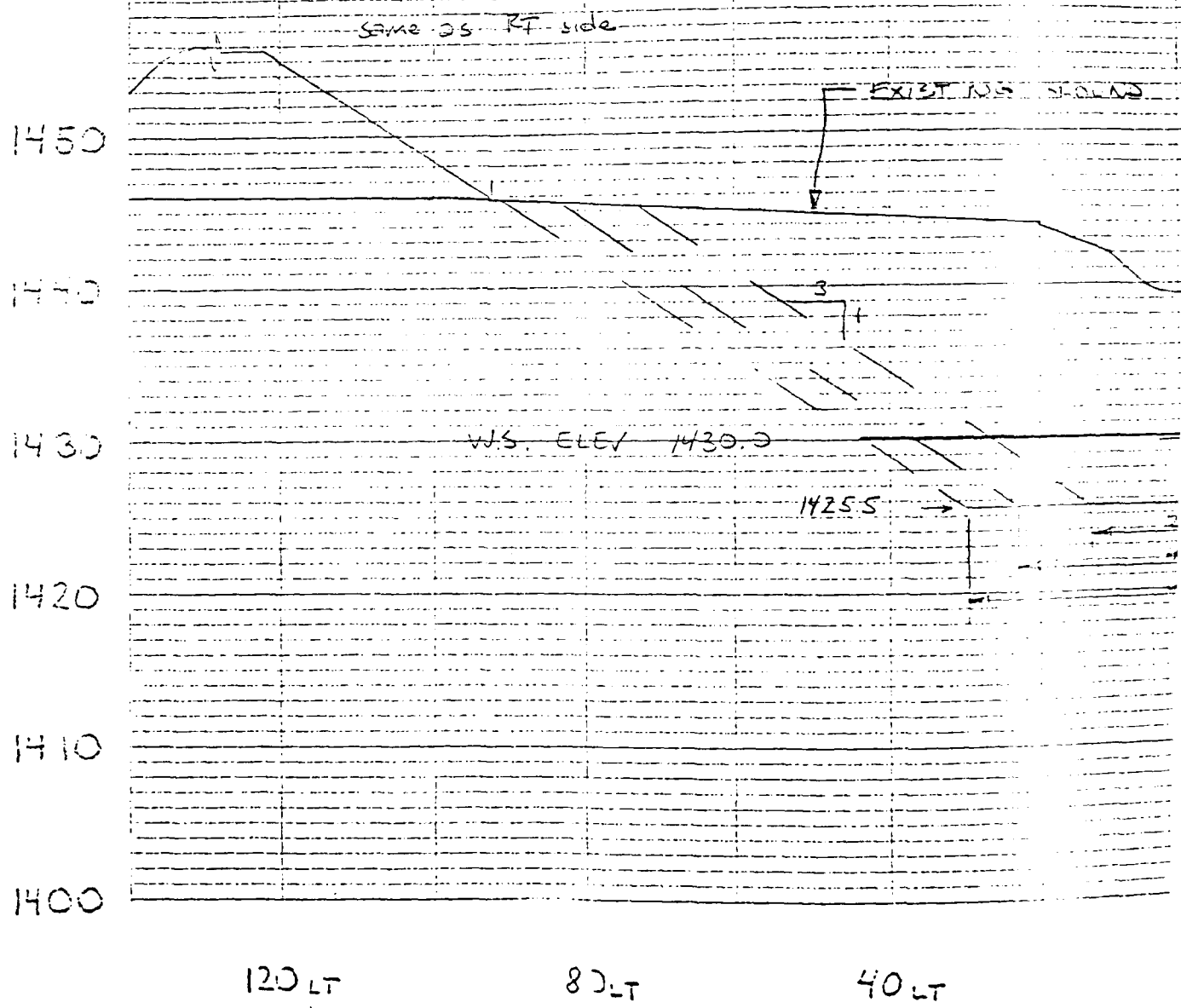






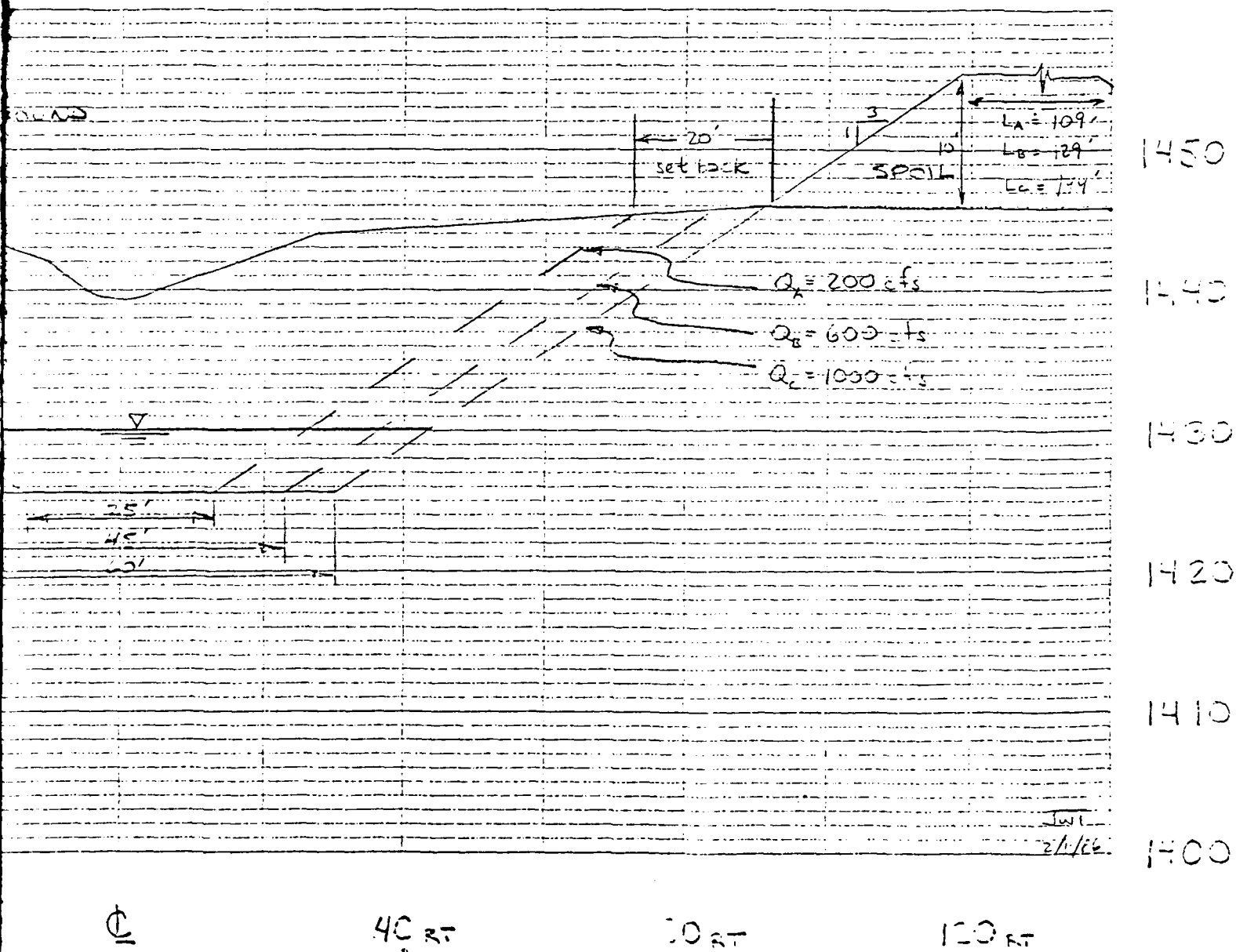
CONNECTING CHANNEL  
EAST DEVILS LAKE TO  
WEST STUMP LAKE  
CASE 5 A, B, & C  
CROSS SECTION STA 485+00





# CONNECTING CHANNEL EAST DEVILS LAKE TO WEST STUMP LAKE

CASE 5A, B, C  
CROSS SECTION STA 514+00



**APPENDIX D**  
COST ESTIMATES

TABLE D-1  
COST ESTIMATE - CASE 1A

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	3,340,000	CY	\$ 0.85	\$2,839,000
CULVERTS				
Cast-in-place	1,663	CY	300.00	499,000
Precast RCP	1,644	LF	50.00	82,200
SLIDE GATES	1	LS	40,000	40,000
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	280	CY	40.00	11,200
ROAD RAISES				
Embankment Fill	1,000	CY	2.50	2,500
Surface Aggregate	460	CY	15.00	6,900
BERMS AND CULVERT BACKFILL	72,700	CY	2.50	182,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	<u>192,000</u>
SUBTOTAL				\$3,881,000
CONTINGENCIES (20%)				776,000
ENGINEERING & DESIGN (10%)				388,000
SUPERVISION & ADMINISTRATION (8%)				<u>310,000</u>
TOTAL				\$5,355,000

D1333,0

TABLE D-2  
COST ESTIMATE - CASE 1B

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	4,719,000	CY	\$ 0.85	\$4,011,000
CULVERTS				
Cast-in-place	4,430	CY	300.00	1,329,000
Precast RCP	1,906	LF	50.00	95,300
SLIDE GATES	1	LS	102,000	102,000
DROP STRUCTURES	2	Ea.	19,200	38,400
CULVERT RIPRAP	630	CY	40.00	25,200
ROAD RAISES				
Embankment Fill	1,000	CY	2.50	2,500
Surface Aggregate	530	CY	15.00	8,000
BERMS AND CULVERT BACKFILL	113,000	CY	2.50	283,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	<u>192,000</u>
SUBTOTAL				\$6,087,000
CONTINGENCIES (20%)				1,217,000
ENGINEERING & DESIGN (10%)				609,000
SUPERVISION & ADMINISTRATION (8%)				<u>487,000</u>
TOTAL				\$8,400,000

D2333,0

TABLE D-3  
COST ESTIMATE - CASE 1C

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	5,696,000	CY	\$ 0.85	\$4,842,000
CULVERTS				
Cast-in-place	7,973	CY	300.00	2,392,000
Precast RCP	2,069	LF	50.00	103,000
SLIDE GATES	1	LS	137,000	137,000
DROP STRUCTURES	2	Ea.	23,100	46,200
CULVERT RIPRAP	952	CY	40.00	38,100
ROAD RAISES				
Embankment Fill	1,000	CY	2.50	2,500
Surface Aggregate	580	CY	15.00	8,700
BERMS AND CULVERT BACKFILL	138,000	CY	2.50	345,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	<u>192,000</u>
SUBTOTAL				\$8,107,000
CONTINGENCIES (20%)				1,621,000
ENGINEERING & DESIGN (10%)				811,000
SUPERVISION & ADMINISTRATION (8%)				<u>649,000</u>
TOTAL				\$11,188,000

D3333,0



TABLE D-4  
COST ESTIMATE - CASE 2G

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	2,287,000	CY	\$ 0.85	\$1,944,000
CULVERTS				
Cast-in-place	1,410	CY	300.00	423,000
Precast RCP	1,417	LF	50.00	70,900
SLIDE GATES	1	LS	40,000	40,000
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	280	CY	40.00	11,200
ROAD RAISES				
Embankment Fill	1,000	CY	2.50	2,500
Surface Aggregate	380	CY	15.00	5,700
BERMS AND CULVERT BACKFILL	49,900	CY	2.50	125,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	192,000
SUBTOTAL				\$2,841,000
CONTINGENCIES (20%)				568,000
ENGINEERING & DESIGN (10%)				284,000
SUPERVISION & ADMINISTRATION (8%)				227,000
TOTAL				\$3,920,000

D4333,0

TABLE D-5  
COST ESTIMATE - CASE 2P

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	2,222,000	CY	\$ 0.85	\$1,889,000
CULVERTS				
Cast-in-place	1,193	CY	300.00	358,000
Precast RCP	1,199	LF	50.00	60,000
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	240	CY	40.00	9,600
ROAD RAISES				
Embankment Fill	1,000	CY	2.50	2,500
Surface Aggregate	380	CY	15.00	5,700
BERMS AND CULVERT BACKFILL	45,000	CY	2.50	113,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	192,000
PUMP STATION	1	LS		<u>1,610,000</u>
SUBTOTAL				\$4,266,000
CONTINGENCIES (20%)				853,000
ENGINEERING & DESIGN (10%)				427,000
SUPERVISION & ADMINISTRATION (8%)				<u>341,000</u>
TOTAL				\$5,887,000

D5333,0

TABLE D-6  
COST ESTIMATE - CASE 3A

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	1,230,000	CY	\$ 0.85	\$1,046,000
CULVERTS				
Cast-in-place	787	CY	300.00	236,000
Precast RCP	1,011	LF	50.00	50,600
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	365	CY	40.00	14,600
ROAD RAISES				
Embankment Fill	8,800	CY	2.50	22,000
Surface Aggregate	1,000	CY	15.00	15,000
BERMS AND CULVERT BACKFILL	31,900	CY	2.50	79,800
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	192,000
PUMP STATION	1	LS		<u>1,610,000</u>
SUBTOTAL				\$3,292,000
CONTINGENCIES (20%)				658,000
ENGINEERING & DESIGN (10%)				329,000
SUPERVISION & ADMINISTRATION (8%)				<u>263,000</u>
TOTAL				\$4,542,000

D6333,0

TABLE D-7  
COST ESTIMATE - CASE 3B

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	1,966,000	CY	\$ 0.85	\$1,697,000
CULVERTS				
Cast-in-place	2,037	CY	300.00	611,000
Precast RCP	1,202	LF	50.00	60,100
DROP STRUCTURES	2	Ea.	19,200	38,400
CULVERT RIPRAP	898	CY	40.00	35,900
ROAD RAISES				
Embankment Fill	8,800	CY	2.50	22,000
Surface Aggregate	1,100	CY	15.00	16,500
BERMS AND CULVERT BACKFILL	43,600	CY	2.50	109,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	192,000
PUMP STATION	1	LS		<u>4,450,000</u>
SUBTOTAL				\$7,232,000
CONTINGENCIES (20%)				1,446,000
ENGINEERING & DESIGN (10%)				723,000
SUPERVISION & ADMINISTRATION (8%)				<u>579,000</u>
TOTAL				\$9,980,000

D7333,0

TABLE D-8  
COST ESTIMATE - CASE 3C

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	2,613,000	CY	\$ 0.85	\$2,221,000
CULVERTS				
Cast-in-place	3,650	CY	300.00	1,095,000
Precast RCP	1,321	LF	50.00	66,100
DROP STRUCTURES	2	Ea.	23,100	46,200
CULVERT RIPRAP	2,189	CY	40.00	87,600
ROAD RAISES				
Embankment Fill	8,800	CY	2.50	22,000
Surface Aggregate	1,100	CY	15.00	16,500
BERMS AND CULVERT BACKFILL	53,900	CY	2.50	135,000
LATERAL INFLOW CULVERTS	24	Ea.	8000.00	192,000
PUMP STATION	1	LS		6,600,000
SUBTOTAL				\$10,481,000
CONTINGENCIES (20%)				2,096,000
ENGINEERING & DESIGN (10%)				1,048,000
SUPERVISION & ADMINISTRATION (8%)				838,000
TOTAL				\$14,463,000

D8333,0

TABLE D-9  
COST ESTIMATE - CASE 4L

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	792,000	CY	\$ 0.85	\$ 673,000
CULVERTS				
Cast-in-place	517	CY	300.00	155,000
Precast RCP	914	LF	50.00	45,700
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	540	CY	40.00	21,600
ROAD RAISES				
Embankment Fill	11,200	CY	2.50	28,000
Surface Aggregate	1,500	CY	15.00	22,500
Riprap	4,050	CY	40.00	162,000
BERMS AND CULVERT BACKFILL	26,500	CY	2.50	66,300
LATERAL INFLOW CULVERTS	22	Ea.	8000.00	176,000
PUMP STATION	1	LS		<u>1,610,000</u>
SUBTOTAL				\$2,987,000
CONTINGENCIES (20%)				597,000
ENGINEERING & DESIGN (10%)				299,000
SUPERVISION & ADMINISTRATION (8%)				<u>239,000</u>
TOTAL				\$4,122,000

D9333,0

TABLE D-10  
COST ESTIMATE - CASE 4H

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	761,000	CY	\$ 0.85	\$ 647,000
CULVERTS				
Cast-in-place	517	CY	300.00	155,000
Precast RCP	914	LF	50.00	45,700
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	540	CY	40.00	21,600
ROAD RAISES				
Embankment Fill	11,200	CY	2.50	28,000
Surface Aggregate	1,500	CY	15.00	22,500
Riprap	4,050	CY	40.00	162,000
BERMS AND CULVERT BACKFILL	26,500	CY	2.50	66,300
LATERAL INFLOW CULVERTS	22	Ea.	8000.00	176,000
PUMP STATION	1	LS		<u>1,610,000</u>
SUBTOTAL				\$2,961,000
CONTINGENCIES (20%)				592,000
ENGINEERING & DESIGN (10%)				296,000
SUPERVISION & ADMINISTRATION (8%)				<u>237,000</u>
TOTAL				\$4,086,000

D10333,0

TABLE D-11  
COST ESTIMATE - CASE 5A

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	363,000	CY	\$ 0.85	\$ 309,000
CULVERTS				
Cast-in-place	517	CY	300.00	155,000
Precast RCP	851	LF	50.00	42,600
DROP STRUCTURES	2	Ea.	13,200	26,400
CULVERT RIPRAP	330	CY	40.00	13,200
ROAD RAISES				
Embankment Fill	236,000	CY	2.50	590,000
Surface Aggregate	8,500	CY	15.00	128,000
Riprap	13,900	CY	40.00	556,000
BERMS AND CULVERT BACKFILL	20,800	CY	2.50	52,000
LATERAL INFLOW CULVERTS	8	Ea.	8000.00	64,000
PUMP STATION	1	LS		<u>1,610,000</u>
SUBTOTAL				\$3,546,000
CONTINGENCIES (20%)				709,000
ENGINEERING & DESIGN (10%)				355,000
SUPERVISION & ADMINISTRATION (8%)				<u>284,000</u>
TOTAL				\$4,894,000

D11333,0



TABLE D-12  
COST ESTIMATE - CASE 5B

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	678,000	CY	\$ 0.85	\$ 576,000
CULVERTS				
Cast-in-place	1,530	CY	300.00	459,000
Precast RCP	963	LF	50.00	48,200
DROP STRUCTURES	2	Ea.	19,200	38,400
CULVERT RIPRAP	1,275	CY	40.00	51,000
ROAD RAISES				
Embankment Fill	236,000	CY	2.50	590,000
Surface Aggregate	8,500	CY	15.00	128,000
Riprap	13,900	CY	40.00	556,000
BERMS AND CULVERT BACKFILL	24,200	CY	2.50	60,500
LATERAL INFLOW CULVERTS	8	Ea.	8000.00	64,000
PUMP STATION	1	LS		<u>4,450,000</u>
SUBTOTAL				\$7,021,000
CONTINGENCIES (20%)				1,404,000
ENGINEERING & DESIGN (10%)				702,000
SUPERVISION & ADMINISTRATION (8%)				<u>562,000</u>
TOTAL				\$9,689,000

D12333,0

TABLE D-13  
COST ESTIMATE - CASE 5C

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Estimated Unit Price</u>	<u>Amount</u>
CHANNEL EXCAVATION	1,032,000	CY	\$ 0.85	\$ 877,000
CULVERTS				
Cast-in-place	2,217	CY	300.00	665,000
Precast RCP	1,031	LF	50.00	51,600
DROP STRUCTURES	2	Ea.	23,100	46,200
CULVERT RIPRAP	1,750	CY	40.00	70,000
ROAD RAISES				
Embankment Fill	236,000	CY	2.50	590,000
Surface Aggregate	8,500	CY	15.00	128,000
Riprap	13,900	CY	40.00	556,000
BERMS AND CULVERT BACKFILL	26,700	CY	2.50	66,800
LATERAL INFLOW CULVERTS	8	Ea.	8000.00	64,000
PUMP STATION	1	LS		<u>6,600,000</u>
SUBTOTAL				\$9,715,000
CONTINGENCIES (20%)				1,943,000
ENGINEERING & DESIGN (10%)				972,000
SUPERVISION & ADMINISTRATION (8%)				<u>777,000</u>
TOTAL				\$13,407,000

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